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THE EPIDEMIC OF BARLEY YELLOW DWARF ON OATS IN 1959

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THE PLANT DISEASE REPORTER

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THE EPIDEMIC OF BARLEY YELLOW DWARF ON OATS IN 1959

H. C. Murphy[1]

INTRODUCTION

In 1959, barley yellow dwarf (BYD) was the most destructive disease affecting oats in the United States. The losses incurred in certain portions of the heavy-oat-producing North Central Region were fully equal to those sustained during years when crown rust and Victoria blight were most destructive. Many oat fields in the heavily affected areas in Missouri, Kansas, Nebraska, South Dakota, Minnesota, Wisconsin, Iowa, Illinois, and Indiana were so severely damaged by BYD as to be not worth harvesting. Although record losses were sustained in certain areas, from a national standpoint the total loss to the oat crop was somewhat less than those suffered from the more widespread epiphytotics of Victoria blight and crown rust in years such as 1947 and 1953, respectively. More widespread epiphytotics of BYD in earlier years, such as 1949 and 1907, also doubtless resulted in greater total loss to the national oat crop than that of 1959.

In the heavily affected areas in the North Central Region, the greenbug appeared to be the principal vector of the barley yellow dwarf virus (BYDV). Although obvious damage from direct greenbug feeding was evident in restricted areas, the typical BYD symptoms and oat varietal reaction indicated that the major damage was caused by BYDV. W. F. Rochow, H. Jedlinski, and others recovered BYDV from many oat specimens collected in the heavily infected areas.

Many observations and reports indicated that oats were generally damaged more severely than barley by BYD in 1959. The greater susceptibility of oats had not been generally observed in previous epiphytotics. The relatively later stage of development of the oat plants, and the possible differences in the species and strains of the aphid vector present, as well as in strains of the virus involved, might account for the heavier infection observed on oats.

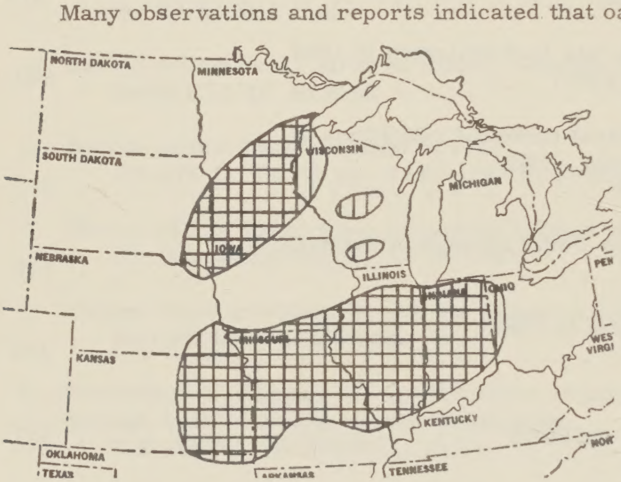

FIGURE 1 Areas of heavy BYD infection in the North Central Region in 1959. (See explanation in text)

Oat varieties and selections previously found to possess some degree of resistance to BYD by Suneson (1957)[2], Endo and Brown (1957), Arny (1959), Endo (unpublished data), and Rochow (unpublished data) were consistent in being outstanding for moderate resistance at all locations in BYD epiphytotic areas where they were observed in 1959. Saia (<u>Avena strigosa</u>), C.I. 7010, and several other diploid strains were highly resistant to BYD at all locations. Among the named agronomic varieties observed by the author to be moderately resistant under epiphytotic conditions at several locations in the North Central Region in 1959 were the following: Albion, C.I. 729; Fulghum, 1915; Newton, 6642; Putnam, 6927; and Tonka (Early Clinton), 7192.

The map (Fig. 1) of the North Central Region shows the approximate areas of heavy BYD infection in 1959. It was prepared on the basis of information in this Supplement; additional information supplied by M. B. Moore, D. E. Western, and other oat workers; 1959 oat variety yield data published by Dreier (1959) and Pendleton and Scott (1959); and personal observations. Severity of infection varied considerably within the marked areas depending upon variety, date of seeding, fertility, and so forth; and varying amounts of BYD infection were present in much of the unmarked areas. The boundaries for the cross-hatched areas, which indicate uniformly heavy infection, were fairly definite, while the areas marked with perpendicular lines indicate spotted infection and lack of adequate observations to establish definite boundaries.

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[2] Literature references refer to bibliography given at the end of this Supplement.

NOTES ON THE EPIDEMIOLOGY OF BARLEY YELLOW DWARF VIRUS IN EASTERN ONTARIO IN 1959[1]

J. T. Slykhuis[2], F. J. Zillinsky[3], M. Young[2], and W. R. Richards[4]

Summary

The isolation of barley yellow dwarf virus (BYDV) from overwintered winter wheat and winter rye, as well as from several species of perennial grasses, indicates that winter reservoirs of the virus are common in eastern Ontario.

Bird cherry oat aphids (Rhopalosiphum padi (L.)) that emerged on Prunus padus, growing at Ottawa, became infective only after they had fed on plants diseased with BYDV. The numbers of R. padi declined in early May before spring oat crops were planted and were seldom found on spring grains until late summer. R. maidis (Fitch.), the corn leaf aphid, became common on barley in June and July. The English grain aphid (Macrosiphum avenae (Fab.)) was observed on spring oats in mid-May before it was found on perennial grasses. The first BYDV infections in spring grains were associated with M. avenae and were scattered over the fields, indicating the vector was initially widely dispersed and had settled down only after prolonged flight. Oats caged in the field on May 20 and 27 remained aphid free, but when caged June 3 to 17, large populations of M. avenae deyeloped, and their feeding reduced yields 40 to 90 percent below the yields of non-caged plants on which the numbers of aphids remained low. BYDV spread in the field from late May to late September, but the rate of spread was most rapid during late June and early July. By mid-July 1 to 5 percent of the plants in most oat fields showed yellow dwarf symptoms. Diseased plants usually occurred in small patches in which yields were reduced as much as 42 percent. The percentage of diseased plants in light stands was higher than in heavy stands of oats.

INTRODUCTION

During the summer of 1958 barley yellow dwarf virus (BYDV) and three aphid vectors, Rhopalosiphum padi (L.) (the bird cherry oat aphid), R. maidis (Fitch.) (the corn leaf aphid), and Macrosiphum avenae (Fab.) (= granarium (Kirby)) (the English grain aphid), were found to be common on spring grains in eastern Ontario (7). The disease was first observed in spring oats on June 20, and incidence of the disease increased as the season advanced. None of the vectors were noticed until late May. The first one observed was R. padi, which appeared to be the most important vector; but M. avenae and R. maidis also became common during the summer. There were variations in the incidence of disease in oats and barley planted in different locations, indicating that local sources of virus and vectors may be important in the inception and development of infections.

Results from further experiments and observations that indicate the local overwintering reservoirs of BYDV, the sources of vectors, and the relationship of vectors to the spread of the viruses in spring grains in 1959 are reported.

WINTER RESERVOIRS OF BYDV

In eastern Ontario a high proportion of the volunteer oats, barley and other annual grasses that are common in the fall are usually infected with BYDV and infested with aphids, but these plants do not survive the winter and are not important as reservoirs of infection of spring grains.

In May 1959 several plants of winter varieties of wheat, barley and oats sown the previous September at the Central Experimental Farm were found with yellow dwarf symptoms, and the virus was isolated from them with M. avenae. The virus was also transmitted from over-

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[1]Joint contribution: Plant Research Institute Contribution No. 31; Genetics and Plant Breeding Research Institute Contribution No. 18; and the Entomology Research Institute, Canada Department of Agriculture, Ottawa, Canada.

[2]Plant Research Institute.

[3]Genetics and Plant Breeding Research Institute.

[4]Entomology Research Institute.

wintered rye by R. padi. Limited acreages of winter wheat and rye are grown in eastern Ontario, but winter barley and oats are not grown except in small experimental plots.

Several workers have shown that many perennial grasses can be infected with BYDV (1, 3). Timothy and perennial ryegrass have been found naturally diseased in Europe (6, 8), and infected timothy has already been reported in Ontario (7). Further tests were conducted to determine if perennial grasses commonly harbor the virus over winter in the Ottawa area.

Samples of perennial grasses were collected to test for BYDV infection. Some plants in experimental nurseries were selected because they were stunted and chlorotic. Other plants were collected at random from lanes and fence rows. The collections were transplanted into pots and boxes to facilitate handling and identifying of the samples. For the transmission tests, succulent young leaves from plants were placed in beakers with moist sand or in test tubes with moist blotting paper. Non-viruliferous R. padi, R. maidis and M. avenae were fed on the leaves for 2 days, then transferred to Clintland oats test plants on which they fed for 2 days before being killed with a malathion spray. The test plants were placed in a greenhouse at about 20° C. Grasses that tested positive were retested to ascertain infection. BYDV was isolated from plants of the following species (Table 1): Phleum pratense, Bromus inermis, Poa pratensis, and Festuca rubra, which are common in the area, and also from Lolium perenne, Agropyron intermedium, and hybrids of Triticum x A. intermedium, which are grown only in experimental plots.

Table 1. Test for BYDV in perennial grasses collected in the vicinity of Ottawa. Clintland variety was used for the oat test plants.

Grass	Samples diseased, of total tested	Symptoms on oats induced by aphids after feeding on grasses		
		M. avenae	R. padi	R. maidis
Agropyron intermedium	2/5	0	mild	0
		mod.	mod.	-
Bromus inermis	3/21	mild	mild	-
		mild	mild	-
		mod.	mild	-
Festuca rubra	1/4	mild	mild	mild
Lolium perenne	2/2	mod.	severe	mild
		mod.	severe	0
Phleum pratense	6/16	mod.	mod.	mod.
		mod.	mod.	mod.
		0	severe	0
		0	severe	0
		severe	severe	-
		mod.	severe	mild
Poa pratensis	1/16	-	severe	mod.
Triticum x Agropyron hybrid.	2/4	mod.	mild	-
		0	0	mild
Agropyron cristatum	0/3			
Agropyron obtusiusculum	0/1			
Agropyron repens	0/4			
Agrostis canina	0/2			
Agrostis palustris	0/1			
Alopecurus pratensis	0/2			
Arrhenatherum elatius	0/1			
Dactylis glomerata	0/1			
Deschampsia caespitosa	0/2			
Festuca arundinacea	0/1			
Festuca pratensis	0/1			
Phalaris arundinacea	0/2			

APHID INCIDENCE IN RELATION TO SPREAD OF BYDV

Since the above results indicate that naturally diseased perennial grasses provide continuing reservoirs of BYDV in eastern Ontario, the time and numbers of aphids moving from perennial grasses into young spring grain crops appear to be of great importance to the

annual initiation and subsequent development of the disease.

There is evidence that all three species of aphids known to be vectors of BYDV in the area can survive the winter in some form in eastern Ontario. R. padi overwinters as eggs on several native and introduced species of Prunus, including P. hortulana, P. nigra, P. padus, P. pensylvanica, P. virginiana, and P. virginiana var. demissa (4). Both R. maidis and M. avenae have sometimes been observed in early spring, presumably having overwintered on grasses in the area. In 1958 R. padi was the first aphid observed in spring oats and appeared to be the major vector of BYDV throughout the crop season. There were also indications that proximity of oats to Prunus padus, on which R. padi eggs overwintered, favoured a high rate of infection early in the summer (7).

Starting on April 13, 1959, inspections for the presence of aphids on known winter hosts and on wild and cultivated grasses were made two to three times weekly at nine locations near Ottawa. Regular inspections were also made to determine the earliest aphid infestations, and the first evidence of disease in spring-sown grains. Dates on which observations of particular interest were noted are as follows:

April 13 -- Aphid eggs, but no aphids, on Sorbus spp., Crataegus spp., and Prunus spp., in the Arboretum at Ottawa.
No evidence of aphids in winter grains or perennial grasses.
Spring grains not yet sown.

April 17 -- Rhopalosiphum padi found on Prunus padus.
Aphids also present on Sorbus spp., and Crataegus spp.

May 4 -- Aphids very scarce on Prunus padus, Coccinelidae very abundant.

May 14 -- A few winged aphids, probably M. avenae, found on spring oats.

May 26 -- Young, wingless as well as a few winged M. avenae were found in some plantings of spring oats which was now in the 2- to 3-leaf stage.

May 29 -- English grain aphids found in spring wheat, and small numbers in most oat fields examined.

June 5 -- Corn leaf aphids found in winter barley.

June 9 -- Yellow dwarf symptoms well developed on scattered plants in a field of spring oats. M. avenae was the only aphid found on the oats.

June 12 -- Rhopalosiphum padi found on spring oats.

June 22 -- M. avenae caught in net sweepings of grass. Corn leaf aphids (R. maidis) common in barley.

July 8 -- First observations of large numbers of R. padi in spring oats, but only in one location.

In April, when aphid eggs were hatching on Prunus padus trees in the Arboretum at Ottawa, several small branches were caged with 32 mesh per inch dacron cloth. This confined the aphids that emerged from eggs and developed on the branches. Some of these aphids were Rhopalosiphum padi. They were tested for infectivity on Clintland oats, but none proved infective until after they had fed on diseased oat plants. By May 4, aphids could be found only rarely on P. padus and other trees on which aphids had been abundant earlier, but Coccinelidae were very abundant and were probably responsible for reducing the aphid numbers. R. padi was not found in oats until June 12; this species was rare until late July, therefore it does not appear to have been important in spreading the virus to spring grains in 1959.

M. avenae was the first aphid species observed in spring grains. It was probably the species observed on May 14. It was definitely present in some oat fields on May 24 and wingless young were found on May 26. On June 9 well developed symptoms caused by BYDV were found in spring oats, along with M. avenae. Although this aphid was never abundant up to the end of July, it was the only aphid commonly found in oats. It appears to have been the primary vector of BYDV in oats in 1959.

R. maidis was not found in barley until June 5, and did not appear to be associated with a noticeable spread of BYDV.

INCIDENCE, DISTRIBUTION, AND EFFECTS OF BYDV IN SPRING GRAINS IN 1959

At weekly intervals during June and July estimates were made of the percentages of diseased plants occurring in plots of Clintland oats, Montcalm and York barley, and Selkirk wheat planted on May 8, in duplicated rod row plots at seven locations on the Central Experimental Farm. Up to June 24 only one plot contained more than 1 percent diseased plants. In this plot percentage infections in the different varieties were, 8 in Clintland, 4 in Montcalm, 2 in York and 0 in Selkirk. This plot was situated at the edge of a bare summer fallowed field. By

July 14 there were no striking differences between plots at different locations. The percentages of infected plants in different plots ranged from 5 to 15 for Clintland, 1 to 10 for Montcalm and York barley, and 2 to 7 for Selkirk wheat.

Between 1 and 5 percent of the plants in most oat fields showed yellow dwarf symptoms by mid-July. There were no examples to show that diseased plants were more abundant at the edges of the fields than in the fields, hence there was no indication that the vector had moved into the fields from adjacent sources. Instead, the initial infections were scattered widely over the fields. Local spread around the initial infections resulted in the development of small groups of diseased plants, and sometimes there were patches several feet in diameter in which up to 75 percent of the plants were diseased. Outside these small groups and patches, very few of the plants were diseased even as late as mid-July.

On July 14 when the plants in a field of 5055-13 oats were in the flowering stage and the symptoms of yellow dwarf were readily distinguishable, four areas containing 30 to 60 percent diseased plants were measured and staked out for harvesting. An area of identical size but with few or no diseased plants was similarly marked within 2 meters of each selected area of diseased plants. When the oats was mature it was harvested and the grain yields measured and compared (Table 2). The yields from the patches of severely diseased plants were 26 to 42.2 percent lower than the yields in adjacent areas which were more representative of the field as a whole. These data highlight the effect of the patchy distribution of the disease and indicate that if the disease had spread more rapidly after its inception into the field, severe yield losses would have resulted.

Table 2. Yield reductions caused by BYDV infections occurring in patches in an oat field.

Area number	Yield per 3 meters of row (in grams)		Percent yield reduction caused by disease
	Diseased patch	Normal plants nearby	
1	119	206	42.2
2	146	204	28.5
3	137	185	26.0
4	128	202	36.6

EFFECTS OF DATE OF CAGING OATS IN THE FIELD

As an aid in determining the date at which vectors of BYDV entered an oat field, cages 1 meter square and 1 meter high, made of lumite saran screen on wooden frames, were set on Clintland oats in a field on eight different dates. The first cage was set out on May 20, the day after the oats was sown, and another was added each week until July 8. Although the oats was observed through the cages each week, the cages were not opened until July 14. At that time the oats was examined to determine the species and approximate numbers of aphids on the plants, and the numbers of plants with yellow dwarf symptoms (Table 3). No aphids of the species known to be vectors were found on the plants caged May 20 or May 27, but large numbers of M. avenae were found on the plants caged on June 3. This indicates that this species infested the oats in this field between May 27 and June 3. Successively smaller numbers of M. avenae were present on plants caged on each of the four dates following June 3, and no aphids were found on plants caged July 8 or on the oats not caged at all. Apparently the cages favored the multiplication of the aphids by excluding predators and by providing other favorable changes in environment. Even though aphid numbers were very high in some cages, there were only six plants with symptoms of yellow dwarf out of 250 in one cage, and five in another, but none were found in any of the others. In the non-caged oats in this field, about one plant per square meter was diseased.

Although the caging experiment just described was not replicated nor otherwise planned for measuring the effects of aphids on yields of oats, large differences seemed inevitable, hence yields were measured (Table 3). The plants from which aphids were excluded by cages set out on May 20 and May 27 produced the highest yields. It is not assumed that the exclusion of aphids was the main reason for increased yields of these plants over yields of the non-caged oats. The weather was hot and dry in early summer, and the plants sheltered by the cages suffered less acutely from drouth, and grew more vigorously. The most striking feature of the results was the inverse correlations between the grain yields and aphid numbers on

Table 3. Effect of date of caging on aphid populations and BYDV infections on Clintland oats.

Date caged	Observations on July 14: Number of diseased plants	Observations on July 14: Estimated numbers of aphids	Grain yield (grams/square meter)
May 20[a]	0[b]	0	136
May 27	0	1 per plant, species undetermined	148
June 3	6	300 per culm, M. avenae	9
June 10	0	250 per culm, M. avenae	15
June 17	0	100 per culm, M. avenae	57
June 24	0	several per culm, M. avenae	114
July 1	5	several per culm, M. avenae	98
July 8	0	rare	92
not caged	1	rare	95
not caged	1	rare	100

[a]Oats seeded May 19.

[b]Diseased plants out of approximately 250 in each cage.

the plants in different cages. The extremely heavy populations of M. avenae caused severe reductions in yield, even when there was little or no evidence of virus.

DATE OF SEEDING IN RELATION TO INFECTION IN OATS

To indicate the rate of virus transmission in the field during the summer and fall, Clintland and Garry oats were sown in duplicated rod row plots at intervals of 2 or 4 weeks from May 1 to September 15. There were about 100 plants in each row. The diseased plants were counted 6 to 8 weeks after seeding, when the maximum numbers showed recognizable symptoms. In the May 1 planting 14 percent of the plants developed disease symptoms. This was comparable to the highest disease counts obtained in other observation plots mentioned before, but higher than the average infection observed in any field of oats in 1959. In the May 15 and June 1 plantings 18 and 21 percent became infected. The highest infection, 29 percent, occurred in the June 15 planting, indicating that the virus spread rapidly in these plots in late June and early July. The low infection, 5 percent, that developed in the July 15 planting indicated a low rate of spread in late July and early August, but an increase in transmission rate was indicated for late August and early September by a 21 percent disease count in the August 15 planting. In the plots sown September 15, yellow dwarf symptoms were observed on one plant before mid-October, when severe frosts damaged the leaves.

PLANT SPACING IN RELATION TO INCIDENCE OF DISEASE

Two susceptible strains of oats, 5055-46 and 4832-3-1-1, were sown in rows 10 feet long and 1 foot apart. The rows were seeded at different rates, with replicates of each rate randomized throughout the planting area. On July 14, 2 months after seeding, counts were made of the numbers of plants per row and the numbers of plants with yellow dwarf symptoms. The two strains of oats were indistinguishable in susceptibility, hence the data for the two are combined in Table 4. Although the incidence of disease in the area of these plots was lower

Table 4. Relationship of plant spacing to incidence of yellow dwarf symptoms in oats.

Number of plants per row	Number of rows	Total number of diseased plants	Number of diseased plants/row	Percent of plants diseased
100	7	8	1.1	1.1
25-50	12	7	0.6	1.9
15-20	8	8	1.0	5.5
10-14	10	12	1.2	11.0
5-9	10	9	0.9	15.5
1-4	14	6	0.4	15.8

than in some nearby fields, the diseased plants appeared to be uniformly distributed throughout the plots. The number of diseased plants per row was remarkably constant, averaging about 1 per row, therefore the percentage of diseased plants was lowest in the rows with the largest numbers of plants.

DISCUSSION

In 1958 R. padi was the most common and probably the most important vector of BYDV in eastern Ontario. There was evidence that local overwintering sources of these aphids contributed to disease development. In 1959 R. padi were observed in April on Prunus spp., but they were exceedingly scarce during June and early July, the most critical period for infection of spring grains. Instead, M. avenae was common and, although not abundant, it appeared to be the most important vector. At least in some years the English grain aphid has been the most important vector of BYDV in New York (5).

Despite careful searching during the spring, M. avenae was not found on perennial grasses until after it had been observed on spring grains. It remains uncertain whether the initial infections in spring grains originated from vectors that acquired the virus from local perennial grasses that harbor BYDV, or from vectors that migrated from considerable distances. The widespread distribution of initial infections does not suggest that the vector moved into spring grains from adjacent or nearby sources, but instead that the vectors had arrived from a distance, or at least that they became widely dispersed before they landed on the spring grains.

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CANADA DEPARTMENT OF AGRICULTURE

OBSERVATIONS ON THE BARLEY YELLOW DWARF VIRUS DISEASE OF OATS IN FLORIDA

H. H. Luke, W. H. Chapman, and P. L. Pfahler[1]

The barley yellow dwarf virus disease of oats has been present in Florida for more than 20 years. Experiment Station records and observations over the past decade indicate that this disease is present, to some degree, each year during the oat-growing season. However, in 1949, 1956, and 1959 the disease was widespread in the northwestern part of the State, but was not prevalent east of the Suwannee River during the past decade. This difference may result from the fact that strains of the virus in the eastern area are not readily transmitted by the endemic species of aphid.

The winter of 1958-1959 was mild, and aphid infestations were heavy during the fall and at various periods during the winter. Therefore, early infection occurred and yellow dwarf symptoms were observed during the first week of March at Gainesville and 2 weeks later at Quincy. Infection spread rapidly and the disease was very prevalent at the North Florida Experiment Station by April 14. Even though 80 percent of the nursery exhibited signs of infection, no distinct sources of resistance were observed. The disease, however, was more prevalent and severe on Camellia and the Red Rustproof types than on some of the earlier maturing varieties, obviously because the late types were exposed to infection longer than the early maturing varieties. It was estimated that the yield of certain late maturing varieties was reduced 5 to 10 percent in the Quincy area.

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BARLEY YELLOW DWARF VIRUS AT TIFTON, GEORGIA IN 1958-59

Darrell D. Morey[1]

Barley yellow dwarf virus caused widespread damage on oats in the Tifton, Georgia nursery in 1959. Plants in rather large areas in fields of Radar 2 oats were severely stunted (rosetted) and grain yields were lower. Barley yellow dwarf virus was isolated by W. F. Rochow from C.I.[2] 7172 and Radar 2 oats collected at Tifton on April 27, 1959. Rochow stated, "The strain in your area appears to be similar to that in many parts of the east in that it was transmitted only by English grain aphids."

Clear-cut resistance to barley yellow dwarf virus was not noticed, but varieties such as Red Rustproof types, C.I. 7171, C.I. 7172, and Radar 2, seemed very susceptible. Over 2000 F_2 head rows of spaced oat plants were practically ruined by the disease. A few single-plant selections were saved, but they may have escaped infection. Barley yellow dwarf virus was more severe on spaced plants and on plants at the ends of rows.

Oats (3318 entries) in the world collection have been planted at Tifton in the hope that these lines from many sources can be evaluated for susceptibility to barley yellow dwarf virus in 1960. About 140 lines from F. A. Coffman are being grown also because they appeared resistant to barley yellow dwarf virus at Aberdeen, Idaho in the summer of 1959.

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[2] C.I. refers to the accession number assigned by Cereal Crops Research Branch, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

BARLEY YELLOW DWARF IN IDAHO IN 1959

Frank C. Petr and Harland Stevens[1]

Plants with symptoms now known to be typical of barley yellow dwarf virus have been observed in experimental and commercial plantings in Idaho for a number of years. The percentage of diseased plants was small and the losses were not of consequence in commercial plantings before 1958. In recent years there has appeared to be a gradual build-up of the disease in Idaho. In 1957 it was necessary to spray some late-planted experimental plots of barley and oats to protect against direct aphid damage and possible virus infection. In 1958 diseased plants appeared in greater frequency in late-planted experimental plots and extension agents and farmers reported greater disease incidence in several agricultural areas of the State. Reduction in quality of some early-planted barley and nearly complete loss of some late-planted fields were observed.

Reports and observations in 1959 indicate widespread distribution of the barley yellow dwarf virus. Damage to commercial fields in southern Idaho was apparent for the first time during the 1959 season, although damage to commercial plantings in northern Idaho was reported in 1958. In both instances, symptoms of and apparent damage from the disease were more evident under conditions of below optimum moisture or above normal temperatures.

In 1959 incidence of the disease in experimental plots at Aberdeen appeared to be proportionately greater on oats than on other grains as compared with previous years. This might indicate a possible shift in the aphid species.

The increased incidence of barley yellow dwarf may possibly be attributed to higher minimum and maximum mean monthly temperatures during most of the spring and early summer in both 1958 and 1959. Under dryland conditions, higher temperatures, coupled with below optimum moisture, resulted in more observable damage, especially blast and sterility of infected tillers of oats and barley. Symptoms similar to those reported by other workers were observed at Aberdeen in 1959. These included the water-soaked areas prior to yellowing, the blackening of tissue at leaf tips, and the premature dying of severely infected plants.

In 1959 certain varieties observed in experimental plots were noticeably more susceptible than others. A late-planted field of Bonneville was plowed under because of almost complete infection of the plants. Craigs-after-lea (C.I. 7026)[2] and some hybrids derived from it were especially susceptible. Black Mesdag appeared to be completely susceptible, while a derived tetraploid, C.I. 7232, was resistant. Progeny of an apparent cross between these showed segregation for resistance and susceptibility[3]. Both Bonneville barley and Craigs-after-lea oats produce abundant foliage. Earlier work at the University of California indicated that some varieties with heavy foliage produce unusually large aphid populations, resulting in a higher incidence of plants infected with yellow dwarf virus.

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BARLEY YELLOW DWARF VIRUS ON OATS IN ILLINOIS IN 1959[1]

H. Jedlinski and C. M. Brown[2]

Summary

The occurrence of barley yellow dwarf on oats in 1959 in Illinois is described. The potential of this disease, which in most years has been considered of only minor importance, was evident in 1959. The reaction and performance of some oat varieties and selections during an epiphytotic year are also reported.

The 1959 Illinois oat crop was severely damaged by a barley yellow dwarf (BYD) epiphytotic. The performance of several oat varieties in advanced nurseries (Table 1 and Table 2) exemplifies the damage sustained in different parts of the State. West-central and central parts of the State appeared to be most severely affected. Many fields were replanted to other crops and many others were not harvested. Similar conditions prevailed in localized areas in east-central Illinois. The damage in the very southern and northern parts of Illinois was much less severe. Generally the damage in these two areas occurred in scattered patches and along the margins of the fields. Throughout Illinois, oats planted on fields of low fertility or those planted late suffered more damage. Oats following soybeans were superior to those following corn where no fertilizer was applied.

IDENTIFICATION OF BYDV INFECTIONS

The barley yellow dwarf virus (BYDV) infection was largely characterized by various degrees of stunting, chlorosis, reddening of the leaves, and necrosis. Many plants failed to develop panicles, and blasting of kernels in various degrees was also fairly prevalent. Close examination of individual plants in the fields suggested strongly that these symptoms were identical with those described for BYD (7, 8, 11, 17, 18). Precise identification of this disease in the field is frequently difficult (7, 15, 17). The symptoms most commonly associated with the disease may also be induced by a number of different factors (5, 6). Therefore, positive identification should be supported by transmission studies.

From the middle of May until the end of July, field samples of what was considered to be BYDV-infected plants were collected in various parts of Illinois. Care was exercised to keep the samples in isolation in order to prevent contamination with aphids naturally occurring on the plants. The collected plants were transplanted to 4-inch pots and covered with insect-proof cages, previously described by Takeshita (Endo) (17). After 1 week the plants were examined for the presence of aphids. In the absence of natural colonies, non-viruliferous Rhopalosiphum padi (L.) were introduced for a 2-day acquisition feeding. Aphids were then transferred onto healthy Clintland oat seedlings, in the two-leaf stage at the rate of five per plant and allowed to feed for 3 days. After killing the aphids with a 0.1 percent malathion spray, the caged plants were incubated in the greenhouse. Two weeks later the indicator plants were examined for positive transmission. The results reported in Table 3 definitely show that the symptoms observed in the field were induced by BYDV infection. Existence of vector specific strains, as reported by Rochow (12, 13), and Slykhuis et al. (14), could explain the inability of the aphid species tested to transmit the virus from some diseased plants.

The yellow dwarf epiphytotic observed in Illinois was associated with large numbers of Toxoptera graminum (Rond.) which appeared toward the end of April and in some areas built up to large populations. Very likely there was some aphid feeding damage in some areas. Fields, however, that were sprayed with insecticides to control the greenbug did not escape heavy infection by BYDV. At the Urbana Agricultural Experiment Station the BYD oat nursery

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[1] Joint contribution of Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Departments of Plant Pathology and Agronomy, Illinois Agricultural Experiment Station, Urbana.

[2] Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Associate Professor, Department of Agronomy, University of Illinois, Urbana, respectively.

Identification of the Rhopalosiphum padi (L.) by H. L. C. Stroyan and M. A. Watson is gratefully acknowledged. Indebtedness is expressed to Dr. W. C. Jacobs for kind assistance in the statistical analysis.

Table 1. Yield, test weight, and percent of yellow dwarf infection of 14 oat varieties grown at several locations in Illinois in 1959[a].

Variety	LOCATION: Brownstown (Southern Ill.) Yield	Brownstown Test Wt.	Brownstown BYD Infec-tion	Hartsburg (West-Central Ill.) Yield	Hartsburg Test Wt.	Hartsburg BYD Infec-tion	Urbana (East-Central Ill.) Yield	Urbana Test Wt.	Urbana BYD Infec-tion	Oneida (W North-Central Ill.) Yield	Oneida Test Wt.	Oneida BYD Infec-tion	DeKalb (North-East Ill.) Yield	DeKalb Test Wt.	DeKalb BYD Infec-tion
	Bu./A	Lbs./Bu.	%	Bu./A	Lbs./Bu.	%	Bu./A	Lbs./Bu.	%	Bu./A	Lbs./Bu.	%	Bu./A	Lbs./Bu.	%
Newton	72	37	5	31	30	43	84	40	10	94	36	10	112	36	5
Putnam	52	31	8	40	31	23	73	38	16	80	37	10	85	37	13
Tonka	69	38	5	28	33	63	84	42	14	74	37	10	103	39	8
Mo. 0-205	58	33	10	26	29	57	67	35	24	86	35	10	97	35	6
Minhafer	61	33	9	24	27	67	63	35	29	76	32	10	100	35	6
Goodfield	51	35	13	17	31	70	53	39	38	67	35	10	107	37	9
Clarion	63	34	8	22	29	83	61	37	39	73	33	10	81	34	10
Nemaha	53	33	14	21	26	77	50	34	43	60	34	10	65	32	16
Fayette	47	26	26	30	26	70	40	30	50	54	28	17	80	32	14
Nehawka	56	33	14	15	25	80	61	34	50	76	32	17	78	33	20
Clinton	50	34	18	9	24	90	43	34	55	60	32	23	67	32	19
Clintland 60	57	31	23	8	24	93	34	33	67	56	31	17	64	31	23
Minton	59	30	19	11	24	97	34	29	78	72	28	13	63	26	28
Clintland	50	32	29	4	24	100	30	33	79	66	32	10	71	32	15

[a] Each figure represents averages of three replications at Hartsburg and Oneida and four at the remaining locations. Estimate of infection was based on percent of plants with visible yellow dwarf symptoms after heading time.

Table 2. Summary and results of analysis of covariance on yield, test weight, and percent of yellow dwarf infection of 14 oat varieties grown at several locations in Illinois in 1959.

Variety	AVERAGE ALL LOCATIONS				
	Yield	Adjusted Yield[a]	Test Wt.	Adjusted Test Wt.	BYD Infection
	Bu./A	Bu./A	Lbs./Bu.	Lbs./Bu.	%
Newton	80.2 a[b]	72.2 a	36.5 a b	35.8 a b	13.3 a
Putnam	66.5 c	58.6 c d e	35.0 a b c	34.3 a b	13.6 a
Tonka	73.8 a b	68.1 a b	38.2 a	37.7 a	18.1 a
Mo. 0-205	67.9 b	63.1 b c	33.5 a b c	33.0 b c	20.0 a b
Minhafer	66.5 c	63.0 b c	32.6 a b c d	32.7 b c	22.5 a b
Goodfield	60.7 c d	59.8 c d	35.8 a b c	35.8 a b	28.1 b c d
Clarion	61.5 c d	60.9 c d	33.6 a b c	33.5 a b	28.6 b c d
Nemaha	50.7 e	51.0 f	32.1 b c d	32.1 b c	30.6 c d e
Fayette	51.1 e	53.2 e f	28.6 d	28.8 c	34.4 d e f
Nehawka	58.5 d e	60.7 c d	31.7 b c d	31.9 b c	34.4 d e f
Clinton	47.1 e	51.3 f	31.5 b c d	31.9 b c	38.6 e f g
Clintland 60	45.0 e	51.6 f	30.3 c d	30.9 b c	43.6 f g
Minton	48.4 e	56.1 d e f	27.5 d	28.2 c	45.8 g
Clintland	45.2 e	53.5 e f	30.9 c d	31.6 b c	47.2 g

[a] Adjusted to the BYD mean 29.9 percent.
[b] Means associated with one or more of the same letters are not significantly different at the 5 percent level; based on Duncan's Multiple Range Test.

Statistics: $b = -.4829$** $\quad$ $b = -.0428$**

$r = -.6317$** when Y = yield and X = B.Y.D. $\quad$ $r = -.4138$** when Y = test weight and X = B.Y.D.

** Significant at 1 percent level.

Table 3. Summary of transmission studies with BYDV from field samples in 1959.

Number of sample	Origin of sample	Plant source	Vector source: Field sample: T. graminum	Field sample: R. padi	Non-viruliferous greenhouse culture[a] of R. padi
1	South-Central Illinois (Brownstown area)	Oat	2/4[b]	5/5	16/18
2	West-Central Illinois (Hartsburg area)	Oat	3/6	4/4	10/10
3	W North-Central Illinois (Oneida area)	Oat	0/0	0/0	10/12
4	North-East Illinois (DeKalb area)	Oat	0/0	0/0	14/15
5	East-Central Illinois	Oat	10/15	6/10	21/24
	(Champaign-Urbana area)	Wheat	0/0	0/0	11/12 and 10/15

[a] Non-viruliferous aphids were tested as checks. In no case did symptoms of BYD develop on Clintland oat plants used as indicators.
[b] Numerator indicates number of samples from which BYDV was recovered and denominator the number of sample plants tested for the virus.

Table 4. Performance of several BYD resistant and susceptible varieties of oats and selections involving their crosses grown at Urbana in 1959.

Variety or cross[a]	Number of replications	Number of selections[b]	Yield per acre (in bushels): Average	Yield per acre: Range	Test weight per bushel (in pounds): Average	Test weight: Range	Percent BYD infection[c]: Average	Percent BYD infection: Range
Albion	6		69	64-73	32	31-33	12	10-15
Newton	6		79	72-87	39	38-39	15	5-25
Fayette	6		50	38-64	31	29-32	36	25-50
Clarion	4		61	49-70	37	36-37	39	25-55
Clintland	6		55	40-71	34	32-35	51	25-75
Albion x Fayette	1	14	80	67-96	31	29-33	8	5-20
Albion x Clarion	1	24	73	58-88	31	27-34	10	5-15
Albion x Newton	1	4	71	66-77	35	34-36	13	10-15
Fulghum x Newton	1	10	78	66-98	35	32-37	10	10-15
Fulghum x Clintland	1	4	76	60-84	35	32-38	10	5-15
(Cherokee x Ark. 674) x Newton	1	7	80	59-91	33	26-37	9	5-15
(Cherokee x Ark. 674) x Fayette	1	5	78	67-90	33	31-37	13	5-25

[a] The varieties Albion and Fulghum are classed as moderately resistant and Newton and Cherokee x Ark. 674 moderately susceptible to BYD. All other varieties are susceptible.
[b] Number of selections replicated once each.
[c] Estimate of infection was based on percent of plants with visible yellow dwarf symptoms.

was periodically sprayed with approximately 0.1 percent malathion. The population of greenbugs was greatly reduced, and consequently the feeding damage, as judged by the decreased number of reddish-brown feeding spots. Yet the prevalence of BYD was essentially the same as in unsprayed parts of the field. No other diseases were observed to be present in damaging amounts.

RESULTS FROM ARTIFICIAL FIELD INOCULATIONS

A section of experimental one-row plots with four hills in each row planted to different varieties and selections is shown in Figure 1, A, B. The first hill in each row was artificially inoculated with BYDV by means of viruliferous R. padi and the other three were left as unin-

FIGURE 1. Reaction of some oat varieties to barley yellow dwarf virus infection. A -- From left to right, 4-hill, one-row plots of Albion, Clintland, Fayette, Newton, Albion x Clarion, Albion x Fayette. In the background, additional crosses with Albion as one of the parents. B -- Close view of the same picture showing the reaction of Clintland.

oculated checks. Little difference could be seen between the inoculated and uninoculated hills. This lack of difference was attributed to the rather early natural infection by BYDV, which was very prevalent in the field. There was, however, a striking difference between the rows as illustrated from left to right: moderately resistant Albion, susceptible Clintland and Fayette, moderately susceptible Newton, and two advanced generations of crosses involving the susceptible and moderately resistant parents Clarion, Fayette, and Albion. A closer view of the highly susceptible variety Clintland is shown in Figure 1, B. Similar reactions of these varieties were observed in previous years by Endo (3) and Endo and Brown[3] (4).

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[3] Unpublished data obtained by R. M. Endo and C. M. Brown.

REACTION OF OAT VARIETIES TO NATURAL INFECTION

Although no resistance to BYD was observed in commonly grown oat varieties when they were artificially inoculated in the greenhouse or in the field[3], some differences were noted in their performance in 1959. Yields, test weights, and percent BYD infection of 14 oat varieties grown at several locations in Illinois in 1959 are shown in Table 1. A summary of the data averaged over all locations along with the analysis of covariance is presented in Table 2. The data clearly show that BYD was a major factor influencing yield at the several locations. Highly significant negative correlations of .6317 and .4138 were obtained between BYD and yield and test weight, respectively, when the random correlation was computed from the analysis of covariance. This indicates that approximately 39 percent of the random variation in yields and approximately 17 percent of the random variation in test weights were accounted for by BYD infection. When correlation coefficients were computed for all observations over all locations the values increased to .8221 and .5930 for yield and test weight, respectively. Likewise, when only variety means were considered, the correlation coefficients increased to .9261 and .8081 for yield and test weight, respectively. Although the over-all correlations between BYD and yield and test weight were very high, the analysis of covariance shows that much of the random variation in yield and test weight was not accounted for by BYD infection as measured by the observations recorded in the tests. Obviously some of this variation was accounted for by normal differences that occur among varieties; however, other factors that could not be accurately differentiated, such as time of infection, differences in virulence of the virus strains, preferential feeding of vectors, could have also contributed to some of the variation in yield and test weight.

Some varieties were damaged more than others. Putnam, Newton, and Tonka (Early Clinton) were observed to be affected less than Clintland 60, Clinton, Clintland, and Minton. Generally, varieties with high BYD infection produced lower yields of grain with somewhat lower test weights. The data show also that BYD damage was much greater at some locations than at others, with west-central Illinois being extremely severe.

BREEDING FOR RESISTANCE TO BYDV

A breeding program designed to produce BYD resistant varieties has been in operation at Illinois for several years. The performance of certain selections that originated from this program might be of special interest to oat workers. Yields, test weights, and percent of BYDV infection of several varieties moderately resistant and susceptible to BYD and selections involving their crosses are shown in Table 4. These selections now in the fifth or sixth generation were made only on the basis of BYD resistance as obtained from artificial greenhouse and field inoculations[3]. It is interesting that most of them performed very well under a rather heavy epiphytotic of BYD at Urbana in 1959, even though they had not been selected for yield or agronomic desirability. For example, the average yield of 14 selections from the cross Albion x Fayette was 80 bushels per acre with a range of 67 to 96, while the average yield of Albion was 69 bushels and of Fayette 50. These data would indicate that susceptible Fayette combined well with moderately resistant Albion to produce selections, many of which performed better than either parent. Many of these selections are of relatively poor agronomic type with little resistance to crown and stem rusts. However, neither rust was a factor influencing yield of oats in Illinois in 1959. It should be emphasized, however, that the true nature of resistance to BYD in oats is not well understood and that the performance of different selections could have also been influenced by factors such as preferential colonization and feeding by vectors, different time of infection, escape, and secondary infections by soil pathogens, as well as by variability in naturally occurring strains of the BYDV.

DISCUSSION

Barley yellow dwarf, first described as an aphid-transmitted virus disease by Oswald and Houston in 1951, has since received increased attention and worldwide distribution (1, 2, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17). The potential of this disease, which in previous years has been considered of only minor importance, was recognized in 1959 in Illinois. The development of resistant varieties appears to be quite promising for BYD control. It should be emphasized, however, that further study of different strains varying in virulence and vector specificity as well as of the vectors and their preferential feeding on the hosts is needed for a full understanding of the epidemiology and practical means of control. Furthermore, the effect of BYD as a predisposing factor to other diseases, especially to root rots, should be explored.

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YELLOW DWARF INFECTION ON OATS AND WHEAT IN INDIANA IN 1959

Ralph M. Caldwell, John F. Schafer, Leroy E. Compton and Fred L. Patterson

Oats in 1959 suffered the most severe attack from the barley yellow dwarf virus yet recorded in Indiana. Damage ranged from little in early sown fields to complete destruction in many later sown fields. Until approximately June 1, oats gave promise of record or near record yields, as they did in 1958 when the State average was 51 bushels per acre. However, the September 1, 1959 estimate of yield by R. E. Straszheim, State-Federal Agricultural Statistician, was only 37 bushels per acre. Moisture was near marginal in some parts of the State for maximum yields, yet at Lafayette, in the driest area of the State, yields commonly exceeded 100 bushels per acre in experimental plots protected from yellow dwarf infection by means of aphid control. Moisture limitation is therefore ruled out as a major factor in yield reduction, except as it may have interacted with yellow dwarf in suppressing plant vigor. In the absence of any other significant disease outbreak or deleterious environmental factor, it is believed that the yield reduction of 1959 may be charged almost entirely to the yellow dwarf disease. On the basis of a potential yield of 51 bushels per acre, as in 1958, the 37 bushel yield of 1959 represents a yellow dwarf loss of 27.5 percent of the oat crop.

Primary infection occurred early and abundantly, resulting in severely stunted plants, and apparently was followed by extensive secondary spread over a period of at least 2 weeks. Both early and later infected plants displayed the characteristic intergrading red to yellow foliage coloration characteristic of the disease.

Other years of serious outbreak have been observed previously, notably 1949, when the disease developed later and resulted in only slight stunting but prevented development of the normal bright yellow straw color. Observation near maturity by oat producers of areas of such off-color straw resulted in the popular designation of the disease as "gray spot." In these spots there was much blasting of florets and the kernels that developed were small and low in test weight. In contrast to this, growers in 1959 were immediately aware of the stunted and brilliantly colored plants at the early shooting stage. Most of the early infected plants failed to head and those heads produced probably averaged not over 18 inches in height. Many severely infected fields were not harvested.

The possibility of comparison of varieties and lines of spring oats in the breeding and test nurseries for resistance or tolerance to BYDV was excluded by the very effective control of spread of the virus with Dimethoate insecticidal sprays. However, in unsprayed and comparable drilled plots of a number of back-cross derivatives of each of the varieties Clintland and Putnam, an excellent comparison was available. The Clintland derivatives were severely injured by yellow dwarf and a large proportion of the tillers were greatly stunted. In contrast, plots of the Putnam derivatives developed vigorously and produced well. Although conspicuous symptoms occurred on some tillers of the Putnam derivatives, it was clear that the visibly affected tillers were fewer and the symptoms generally milder than in the adjacent derivatives of Clintland.

Winter wheat also showed extensive symptoms characteristic of infection with barley yellow dwarf virus. Such symptoms have been observed rather extensively in previous years, but have never approached the abundance displayed in 1959. The chief symptom was the intergrading foliage color from bright red to yellow. Stunting was not obvious, nor was damage apparent. Varieties that normally produce reddish colored straw and sheaths showed the symptoms most strikingly. Flag leaves of such varieties as LaPorte developed brilliant red color in the flag leaves. Many fields were observed in which nearly 100 percent of the plants displayed symptoms. Yellow strawed varieties showed mainly yellow or pinkish-yellow flag leaf colors.

Experiments attempting to transfer the virus to oat seedlings were not successful; however the results are of little value owing to high greenhouse temperatures encountered. Transfers from field infected oats to oat seedlings were also negative. It is tentatively assumed that a high percentage of winter wheat as well as oats was infected with BYDV in 1959.

The average wheat yield for the State as of August 1 has been estimated by the Federal-State agricultural statisticians at 26.0 bushels per acre as compared with a record 32.0 bushels per acre in 1958 and an average of 24.8 bushels per acre for the 10-year period 1948 to 1957. In view of reduced wheat stands resulting from winter injury in 1958-59, it appears that 26.0 bushels per acre represents a relatively high yield for this year. Therefore it follows that yellow dwarf may have caused little yield reduction in wheat despite a presumed high level of infection.

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PROTECTION OF OATS AGAINST TRANSMISSION OF BARLEY YELLOW DWARF VIRUS THROUGH CONTROL OF APHIDS WITH DIMETHOATE[1]

Ralph M. Caldwell, M. Curtis Wilson and John F. Schafer[2]

The yellow dwarf (red leaf) disease of oats, caused by the barley yellow dwarf virus, was observed at a relatively early date (May 13) in the spring oat experimental plots at Lafayette, Indiana, in 1959. At this time unusually heavy populations of the English grain aphid (Macrosiphum granarium (Kby.)) and the greenbug (Toxoptera graminum (Rond.)) were also found. An attempt was therefore made to control the aphid populations in an effort to prevent disastrous further spread of the disease by these vectors.

The oat foliage on the experimental plots was sprayed on May 20 with a systemic insecticide, Dimethoate (0, 0-dimethyl S(N-methylcarbamoyl-methyl) phosphorodithioate), at the rate of 2/3 pint (containing 46 percent soluble concentrate) in 15 gallons of water per acre at 80 pounds' pressure. The spray was applied with a tractor mounted sprayer. This application produced no obvious damage to the host. In examinations made almost daily, beginning on the first day after spraying, no living aphids were found. This freedom from aphids was maintained for at least 2 weeks and until the population of aphids became greatly reduced naturally on nearby unsprayed oats. There was no apparent subsequent build-up of aphid populations in the sprayed plots, although routine detailed examinations were not continued after 2 weeks.

The sprayed plots contained oat experiments seeded at an early, a medium, and a late date of seeding. The entire nursery was sprayed in the interest of the original experimental plan, thus providing no check on the effect of the spray on yields. However, "filler" oats of the Clintland variety seeded around the experimental plots were not sprayed except where the sprayer was turned around at the ends of the plots. These filler oats, seeded at the time of the latest experimental planting on May 1, provided an excellent check on the development of the disease in comparison with the several varieties seeded in four replications at the latest date of seeding (Fig. 1).

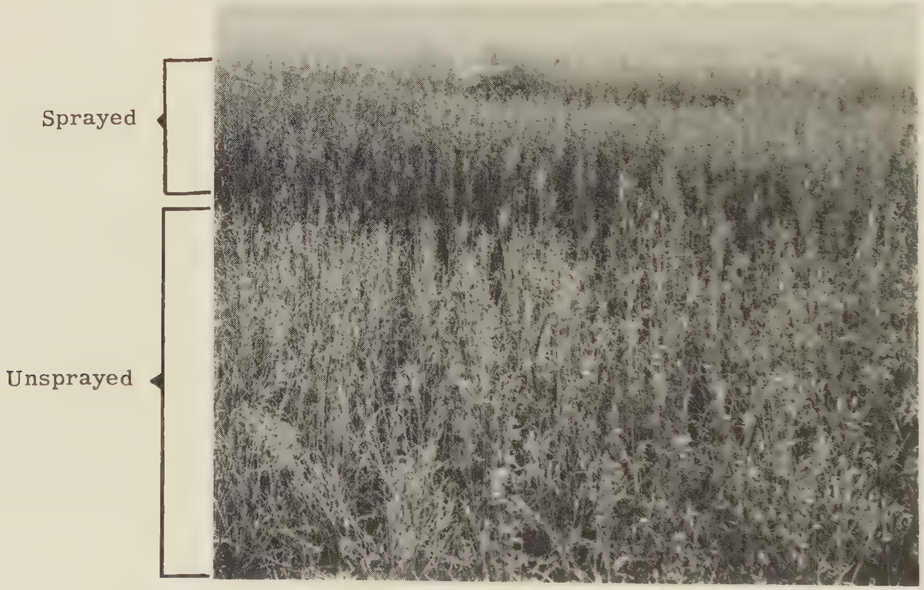

FIGURE 1. Control of transmission of the barley yellow dwarf virus in oats by a single spray of a systemic insecticide, Dimethoate. Foreground shows diseased plants in the unsprayed area; background shows normal plants, sprayed 20 days after seeding. Taller plants in rear were seeded earlier and also sprayed.

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[1]Purdue University Agricultural Experiment Station, Journal Paper No. 1532.

[2]Respectively, Professor of Botany and Plant Pathology, Assistant Professor of Entomology, and Professor of Plant Pathology, Purdue University.

The yellow dwarf disease was devastating to late seeded Clintland oats over areas of several acres. The plants were 100 percent infected, greatly stunted, and most tillers failed to produce fruiting panicles. The better panicles produced were not over 18 inches high. The crop was a total loss and was not harvested. In contrast, the adjacent sprayed plots seeded at the same time produced nearly normal stands of fruiting tillers with very satisfactory yields for the delayed seeding date. Clintland yielded 76.3 bushels per acre in four sprayed replications. There was no unsprayed check for comparison with the sprayed early and medium season seedings.

The proportion of diseased tillers was not accurately determined in the sprayed plots; however, it was evident that some infection had occurred. It is estimated that approximately 10 percent of the tillers in the sprayed plots showed some symptoms of yellow dwarf previous to ripening. This infection could have occurred before the sprays were applied. Inasmuch as sprayed plots were adjacent to the large unsprayed areas of BYDV infected oats where heavy aphid populations existed, it seems apparent that the Dimethoate provided prolonged protection against spread of the virus by aphids migrating from the unsprayed areas.

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YELLOW DWARF OF OATS IN IOWA IN 1959[1]

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Summary

Yellow dwarf of oats was severe in southeastern and northwestern Iowa in 1959 and caused a reduction in yield estimated at 12 percent for the entire State. Significant positive correlations between yellow dwarf ratings of varieties in three oat-variety tests were obtained, and significant negative correlations between yellow dwarf ratings and yields were obtained. Putnam and Newton varieties were resistant to the yellow dwarf disease; Richland, Bonham, Cherokee, Nemaha, Minhafer, Clarion, Burnett, Beedee, C.I. 7154, Macon, and Nehawka were intermediate in response; and Fayette, Clintland, Clinton, Clintland 60, Sauk, Garry, C.I. 7272, Goodfield, and Minton were susceptible. Yellow dwarf was most severe in fields of low fertility and with sparse stands.

Yellow dwarf of oats, caused by the barley yellow dwarf virus, was epiphytotic in some areas of Iowa in 1959. Occasional fields were severely infected throughout the State, but the areas affected most severely were in southeastern and northwestern Iowa (Fig. 1).

Several papers (4, 5, 6) have reported large yield reductions from artificially induced yellow dwarf epiphytotics on oats, but loss estimates under natural conditions are scarce (1). Three locations (Seymour, Olds, and Doon) where the 1959 Iowa oat-variety tests were grown were in yellow dwarf-affected areas (Fig. 1). This paper reports data from these tests and observations in farmers' oat fields in these areas. No other oat diseases occurred in appreciable amounts in Iowa in 1959.

DATA FROM OAT-VARIETY TESTS

The oat varieties grown in the Seymour, Olds and Doon yield trials reacted differently to the yellow dwarf disease as evidenced by yellow dwarf ratings, yields, and test weights (Table 1). The Seymour nursery was not harvested because of poor stands. Data from another nursery, located at Sutherland, were included in Table 1 as a yellow dwarf-free check.

Yellow dwarf was rated on a scale of 1 to 5 (5 being most severe) at each location. Since yellow dwarf ratings were relative for varieties at a given location, the same numerical rating in different tests does not necessarily indicate the same severity of yellow dwarf. While yellow dwarf differed in severity from one location to another, the relative ratings for varieties were similar among tests. This observation is indicated by the highly significant correlations (Table 2) ranging from +0.63 to +0.78 for yellow dwarf ratings among locations. Putnam and Newton gave the lowest yellow dwarf ratings in all tests, whereas Fayette, Clintland, Clintland 60, and Sauk were most severely affected (Figs. 2 and 3). Putnam and Fayette are early-maturing varieties, Newton, Clintland, and Clintland 60 are midseason, and Sauk is a late-maturing variety (Table 1).

The correlations between yellow dwarf ratings and yields at Doon and Olds were both negative and significant, indicating that yields were depressed by the yellow dwarf disease. The correlation coefficient between yellow dwarf ratings and test weights at Olds was -0.46. A similar correlation could not be calculated for the Doon location since some varieties did not produce enough seed for test weight measurements.

Another method of showing the effect of yellow dwarf on oat yields would be to compare the yield of each variety subjected to infection in 1959 with the respective yields from a test where the disease was not present. Such a comparison is presented in Table 3 where all yields are expressed as percentages of the respective test means. Since both years were excellent for oat production, and diseases other than yellow dwarf in 1959 were not prevalent in either year, the differences that a variety expressed in percentage yield from one year to the next would be a measure of resistance to yellow dwarf.

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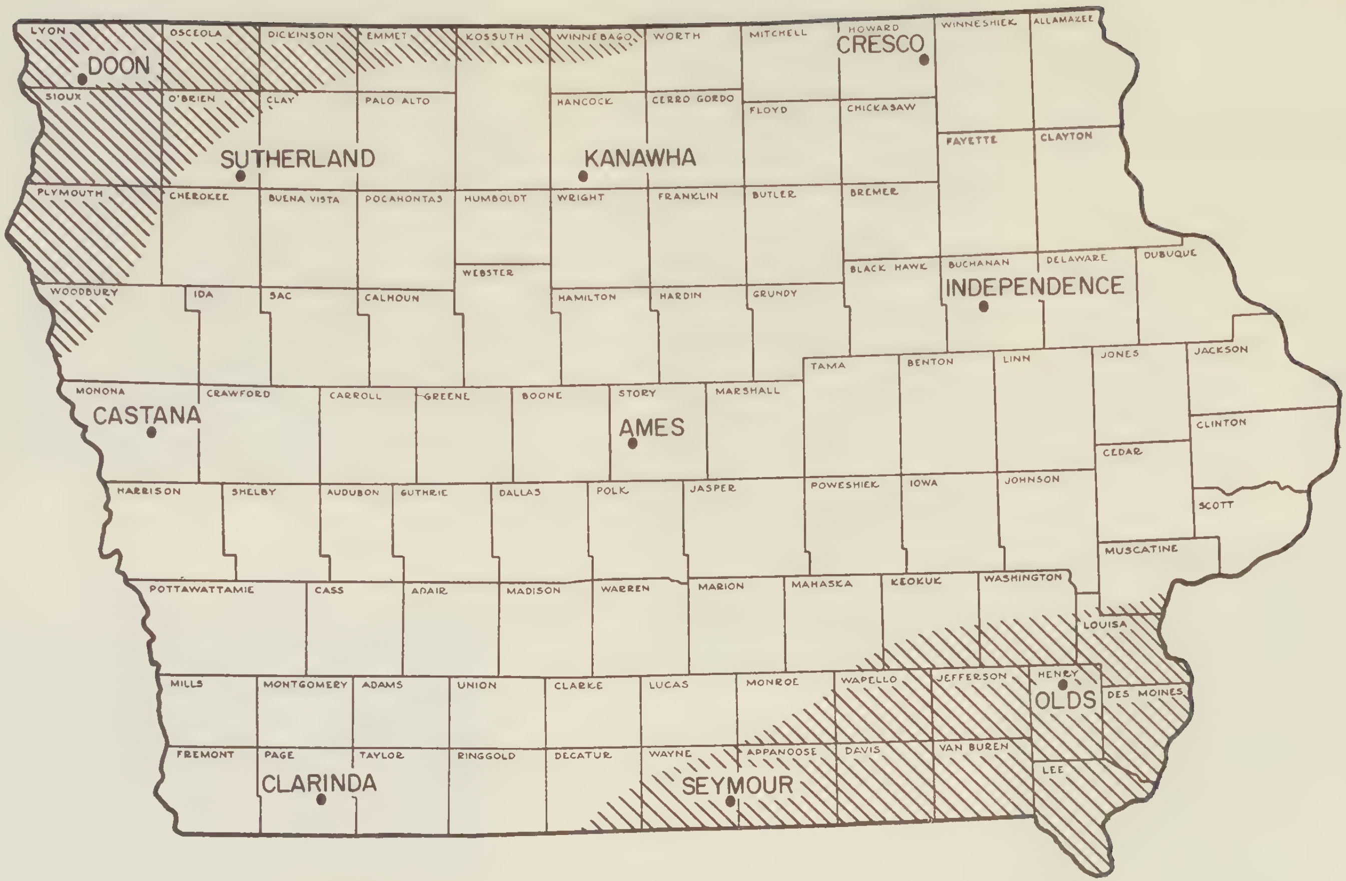

FIGURE 1. Iowa small grain-testing stations and approximate areas of Iowa where oats were affected severely with yellow dwarf in 1959.

FIGURE 2. Effect of severe yellow dwarf on Newton and Sauk oats in 3-row plots at Doon, Iowa in 1959.

FIGURE 3. Effect of severe yellow dwarf on Putnam, Fayette, Minhafer, and Clintland oats in 3-row plots at Doon, Iowa in 1959.

FIGURE 4. Two fields of oats in the same locality of Plymouth County, Iowa in 1959. A -- Yellow dwarf in oats on Ida-Monona type soil. B -- Yellow dwarf-free oats on Galva-Primghar type soil.

Table 1. Yellow dwarf ratings, yields, and test weights of entries in the 1959 Iowa oat variety test[a].

Variety	C.I. No.	Maturity class[b]	Yellow dwarf ratings[c]				Grain yields in bushels per acre				Test weights		
			Seymour	Olds	Doon	Av.	Olds	Doon	Sutherland	State Average 10 locations	Olds	Doon	Sutherland
Newton	6642	M	2.0	1.3	1.0	1.4	91	59	95	89	34.5	31.2	34.7
Putnam	6927	E	1.7	1.0	1.7	1.5	86	57	79	83	35.7	32.6	33.8
Minhafer	6913	E	2.0	3.0	1.3	2.1	77	37	100	90	32.0	29.7	31.7
Beedee	6752	M	3.3	2.0	2.7	2.7	85	40	99	85	35.2	35.7	34.2
Macon	6625	E	3.7	2.3	2.0	2.7	82	36	90	81	35.0	29.6	33.2
Nemaha	4301	E	2.7	2.7	3.0	2.8	83	24	82	79	34.0	24.8	33.4
Cherokee	5444	E	4.0	2.3	3.0	3.1	87	36	84	78	34.1	27.6	33.4
---	7154	E	4.7	2.0	2.7	3.1	97	27	100	86	34.6	27.5	33.4
Clarion	5647	M	3.3	3.3	3.0	3.2	84	31	99	79	34.0	31.2	33.5
Bonham	4676	E	3.7	3.0	3.0	3.2	80	35	91	81	32.7	29.5	33.8
Garry	6662	L	3.3	2.3	4.3	3.3	77	13	101	80	31.1	25.6	32.8
Richland	787	E	4.3	2.7	3.3	3.4	73	27	88	72	32.1	25.6	31.1
Nehawka	7194	E	4.3	3.0	3.7	3.7	95	28	101	86	33.0	28.8	33.5
Goodfield	7266	M	3.0	3.0	5.0	3.7	74	16	86	78	35.1	31.4	34.7
---	7272	E	3.7	3.7	4.0	3.8	82	21	86	82	34.7	29.0	33.6
Burnett	6537	M	4.3	3.7	4.0	4.0	94	24	104	85	34.9	28.6	34.6
Minton	6935	M	4.0	4.0	4.7	4.2	66	18	103	78	30.3	27.8	30.1
Clinton	4259	M	4.0	4.0	4.7	4.2	67	10	84	70	32.2	--	33.5
Clintland 60	7234	M	4.7	4.0	4.7	4.5	76	11	81	76	33.5	--	32.6
Sauk	5946	L	5.0	3.7	5.0	4.6	82	6	103	82	31.7	--	32.8
Clintland	6701	M	4.7	4.0	5.0	4.6	71	5	75	74	33.4	--	32.0
Fayette	6916	E	4.7	4.0	5.0	4.6	72	11	76	71	32.9	23.0	33.1
Mean							81	26	91	80			

[a] All data are means of three replications at each location.

[b] E = Early, M = Midseason, L = Late.

[c] Severity of response to yellow dwarf rated from 1 to 5, with 5 most severe.

Table 2. Correlation coefficients between yellow dwarf ratings, grain yields, and test weights for oat variety tests grown at Seymour, Olds, and Doon, Iowa, 1959.

Items correlated	Correlation coefficient	Degrees of freedom
Yellow dwarf at Doon and Olds	+.78**	20
Yellow dwarf at Doon and Seymour	+.70**	20
Yellow dwarf at Seymour and Olds	+.63**	20
Yellow dwarf and yield at Doon	-.92**	20
Yellow dwarf and yield at Olds	-.54**	20
Yellow dwarf and test weight at Olds	-.46*	20
Yellow dwarf and test weight at Doon	-.44	16

** Significant at the 1 percent level.
* Significant at the 5 percent level.

Table 3. Variety yields in percentage of means of experiments at Olds, Doon, and Sutherland, Iowa in 1958 and 1959.

Variety	Olds 1959	Olds 1958	Doon 1959	Doon 1958	Sutherland 1959	Sutherland 1958
Putnam	106	96	204	79	87	93
Newton	112	110	211	105	104	103
Cherokee	107	90	129	93	92	96
Beedee	105	103	143	108	109	107
Bonham	99	103	125	87	100	96
Minhafer	95	104	132	97	110	98
Clarion	104	102	111	109	109	100
Nemaha	102	91	86	90	90	97
Richland	90	93	96	96	97	98
Burnett	116	109	86	110	114	106
Fayette	89	84	39	92	84	91
Garry	95	114	46	135	111	98
Clinton	83	104	36	88	92	104
Clintland	88	84	18	100	82	103
Sauk	101	119	21	121	113	109
Means (bushels per acre)	81	96	28	92	91	112

In the Doon test, Putnam yielded 79 percent of the mean in 1958 and 204 percent in 1959. Newton percentages were 105 and 211 for 1958 and 1959, respectively. In contrast, Clintland yielded 100 percent of the mean in 1958, but only 18 percent in 1959, and Sauk yielded 121 percent and 21 percent for the 2 years, respectively. The varieties most widely grown in Iowa, Cherokee, Bonham and Nemaha, all early-maturing varieties, averaged a somewhat higher percentage yield in 1959 than in 1958. The percentage yield data indicated that Putnam and Newton were resistant to yellow dwarf, but they do not imply that these varieties were unaffected by the disease. These percentages simply mean that, relative to other varieties, Putnam and Newton were resistant. In terms of actual yields, Putnam and Newton produced 25 percent less grain in 1959 than in 1958 at the Doon location. In contrast, Clintland and Sauk produced 95 percent less in 1959.

The relative yields at Olds tend to corroborate the conclusions drawn from data obtained at Doon, but they are much less extreme. At Sutherland the 1958 and 1959 relative yields of the respective varieties were associated well, which was to be expected since neither yellow dwarf nor any other disease was severe at this location in either year.

Varieties fell into three distinct groups for response to yellow dwarf. The most susceptible varieties were Fayette, Clinton, Clintland, Clintland 60, Sauk, and Garry, and C.I. 7272, Goodfield, and Minton were slightly less susceptible. Richland, Bonham, Cherokee, Nemaha, Minhafer, Clarion, Burnett, Beedee, C.I. 7154, Macon, and Nehawka were intermediate in reaction, and Newton and Putnam were resistant.

The reduction in Iowa oat yields due to yellow dwarf in 1959 was estimated at 12 percent. Yellow dwarf was less severe than in 1949, the only previous epiphytotic year, when it was more evenly distributed over the State and caused an estimated reduction in yield of 15 percent. In 1959, however, yellow dwarf was more devastating in individual fields than it was in 1949. In fact, it was more devastating in certain fields than either Victoria blight or crown rust in years when these "major" oat diseases were epiphytotic[3].

OBSERVATIONS FROM FARMERS' FIELDS

In previous years, when yellow dwarf was present in Iowa, it first appeared on barley and then spread to oats. Symptoms of yellow dwarf have been observed repeatedly to develop progressively from south to north in oats immediately north of barley. This sequence of development is apparently correlated with the wind-movement of the vector, as prevailing winds in the summer in Iowa are from the south. However, in 1959 yellow dwarf hardly affected barley, even when the two crops were grown side-by-side.

Yellow dwarf was more severe in fields with sparse stands, as Slykhuis et al. (5) observed in Ontario. Invariably the most severe yellow dwarf in the breeding nursery at Ames, Iowa is in the space-planted rows. In space-planted nurseries there is more opportunity for the aphid vectors to be blown from plant to plant than there is in a solid stand. A sparse stand in a farmer's field would be somewhat comparable to a space-planted nursery. In contrast, a full stand of oats presents a formidable barrier to wind and also to aphid movement. When yellow dwarf has been observed to move into oats from perennial grasses in the fence row, plants well into, if not throughout, a sparse field have shown yellow dwarf symptoms. However, in a full stand only a few plants in the peripheral few feet may show symptoms.

Yellow dwarf was more serious in fields low in fertility. Fertility level may manifest its effects through the plant, the disease, the vector, or the interaction among them. Aphids have been reported (2, 3) more numerous but less damaging on small grains supplied with nitrogen, but the effect of fertility on the disease is not known.

Yellow dwarf in Iowa in 1959 was more severe on oats following corn than on those following soybeans. This could be related to nitrogen in the soil. Oats growing on Ida-Monona soil (Fig. 4A) had considerable yellow dwarf whereas those on Galva-Primghar soil (Fig. 4B) in the same locality were essentially free of yellow dwarf. This could also be related to the fertility level of the two soil types. The influence of fertility level on yellow dwarf incidence is complex, but undoubtedly low fertility is related to sparse stands.

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BARLEY YELLOW DWARF IN KANSAS OATS AND BARLEY IN 1959[1]

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The most severe outbreak of barley yellow dwarf virus on record occurred in Kansas spring oats and spring barley during 1959. The disease occurred also in winter barley but was much less damaging and, in general, the percentage of infected plants was much lower than in the spring-planted fields. This disease has been seen previously in Kansas (4) but usually has not been severe.

Several aphids have been shown to transmit this virus (2). Aphid populations, particularly greenbugs, Toxoptera graminum Rond., were very high in eastern Kansas in both the fall of 1958 and the spring of 1959. Peak greenbug populations occurred during the last week of April and the first week of May and were considerably higher than normal during the entire spring. Greenbug feeding damage also was severe in the eastern half of the State during the spring and it was difficult at times to distinguish between this injury and virus symptoms and damage. Most observers consulted believed, however, that the virus damage in 1959 was greater than the greenbug injury.

Disease symptoms on both oats and barley were typical of those previously described in detail (1, 2, 3, 5, 6).

Varietal reactions to barley yellow dwarf in oats (red leaf) were recorded in the nurseries at Manhattan in Riley County and Powhattan in Brown County. The distribution of greenbug and red leaf was variable at Manhattan but appeared to be uniform at Powhattan. Kanota, Kanota derivatives, and Richland x Fulghum lines were outstanding in their lack of evident red leaf symptoms and in performance. Ratings on severity of red leaf were made on the following basis: slight (1, 2, or 3); average (4, 5, or 6); and severe (7, 8, or 9). Red leaf ratings, yield in pounds per acre, and test weight in pounds per bushel of named varieties are given in Table 1.

Table 1. Red leaf ratings, yield, and test weight of spring oat varieties grown in replicated performance trials at Manhattan and Powhattan, Kansas in 1959.

Variety	C. I. number	Manhattan R. L. rating	Manhattan Yield (lbs./acre)	Manhattan Test weight (lbs./bushel)	Powhattan R. L. rating	Powhattan Yield (lbs./acre)	Powhattan Test weight (lbs./bushel)
Kanota	639	1.0	2040	29.9	2.0	2024	34.1
Columbia	2820	4.0	1801	30.3	3.5	1393	31.5
Osage	3991	3.2	1623	28.0	4.2	1493	33.1
Mo. 0-205	4988	4.0	1633	30.8	4.0	1269	33.8
Andrew	4170	4.2	1324	28.2	3.2	1438	32.0
Putnam	6927	4.7	1120	32.1	2.0	1449	34.1
Macon	6625	5.7	1166	31.1	3.5	1329	34.0
Nehawka	7194	7.5	993	30.0	4.7	893	32.1
Minhafer	6913	8.0	596	28.0	4.0	1073	29.4
Clinton 59	4259	7.0	945	29.7	8.0	526	32.5

The ratings are averages of four readings at each location. The varieties are listed in order from highest to lowest average yield at both locations. In general, the higher the red leaf rating the lower was the yield. There was good agreement in disease response readings between the two locations except with Putnam and Minhafer. In general the tillers that produced grain appeared normal. The damage done was primarily one of reduced number of panicle-bearing tillers. There was also considerable early loss of leaves in susceptible vari-

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The authors acknowledge with thanks the information furnished by R. H. Painter and C. O. Johnston at this Station.

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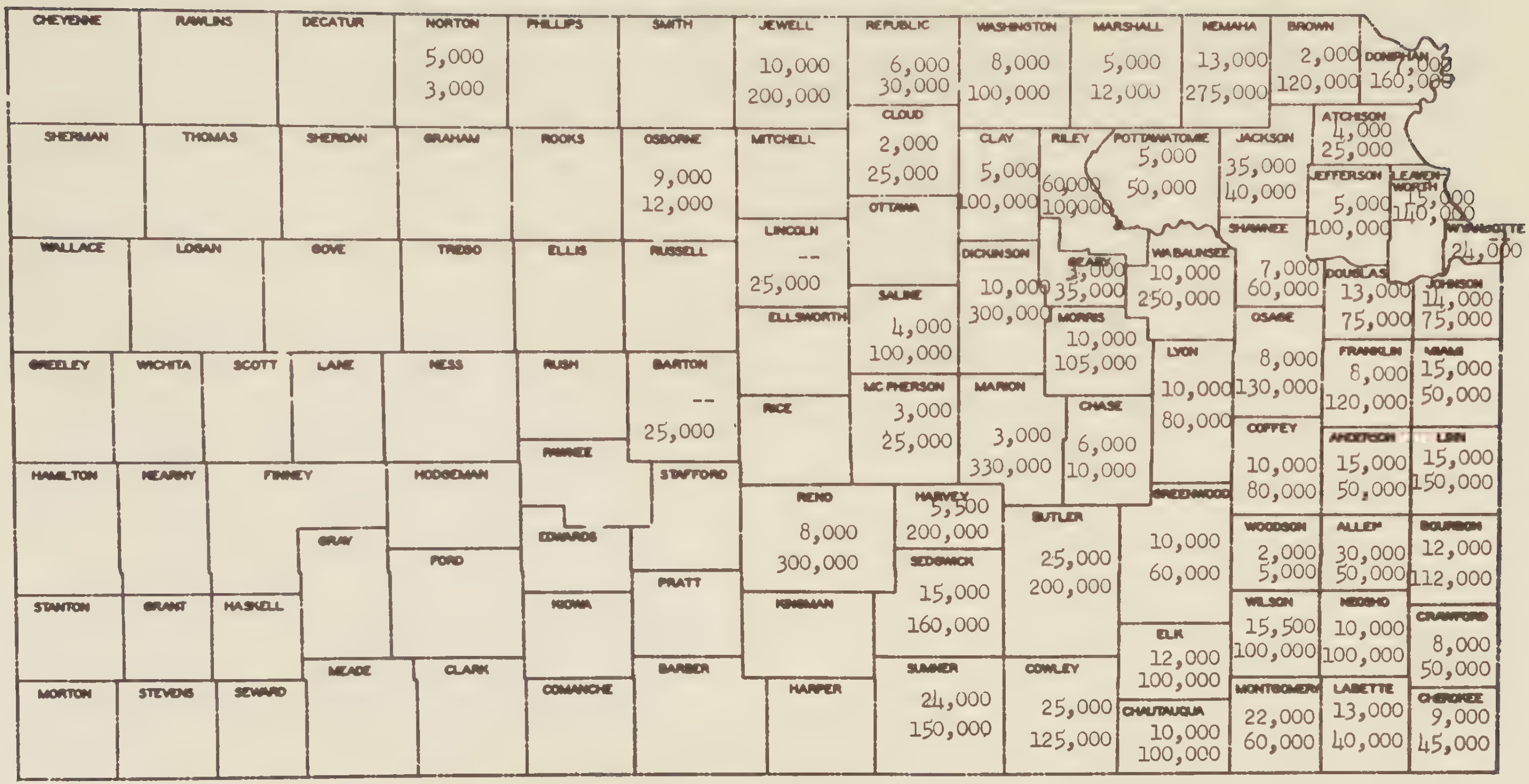

FIGURE 1. Estimated county losses due to barley yellow dwarf in oats and barley in Kansas: 1959 crop. Top number in each county is the bushel loss in barley. Total -- 562,000. Bottom number is the bushel loss in oats. Total -- 5,923,000.

eties. Other factors also influenced yield, especially the drouthy conditions at Manhattan, and, of course, greenbug damage. General observations throughout the State also indicated that the oat varieties Cherokee and Nemaha were quite susceptible, while Kanota appeared to be very resistant and Mo. 0-205 and Andrew moderately resistant.

Estimates of losses caused by barley yellow dwarf in Kansas in 1959 were made by the writers in cooperation with county agricultural agents in affected counties. Losses in some oat fields were estimated as high as 50 percent or more and often were 25 to 40 percent. Infection of individual plants, based upon field counts of red leaf plants, frequently was 50 to 75 percent and occasionally was higher. Late planted fields usually had a higher percentage of diseased plants. Losses estimated for oats in each county are presented in Figure 1 and represent the most accurate loss estimates available from all sources. The total State loss, occurring mostly in eastern counties, was estimated at 5,923,000 bushels on 481,000 acres, or approximately 25 percent of the 1959 oat crop.

Heavy greenbug infestation occurred in winter barley in the fall of 1958 in the Manhattan field plots in northeastern Kansas and spread to the nearby winter wheat. Barley yields in these plots were much lower than expected under the prevailing conditions. The higher yielding varieties were those known to have some resistance to greenbug. Hence, there was undoubtedly considerable loss from greenbug damage and an unknown but probably significant loss resulting from barley yellow dwarf.

In general losses in winter barley, particularly in northwest counties, were not severe, owing probably to the time of planting and harvesting and to smaller aphid populations. Only three winter barley fields with more than 10 percent infected plants were seen.

In spring barley six fields were seen in eastern Kansas which were a total loss and all late planted fields seen were very badly damaged. As shown in Figure 1, approximately 35,800 acres of barley, largely in the eastern half of the State, were diseased. Total loss estimates were 562,000 bushels or 2.3 percent of the 1959 State crop.

Although there is no direct evidence of barley yellow dwarf virus infection of winter wheat in Kansas in 1959, considerable indirect evidence indicates that this may have occurred, particularly in eastern counties where the disease was common in oats. Wheat yields in these eastern counties, especially in early planted winter wheat, were considerably below preharvest expectations. Losses from wheat streak mosaic virus and soil-borne wheat mosaic virus were known to be slight in eastern Kansas. Leaf rust of wheat, several head blights, and foot rots, including take-all, caused considerable damage but, according to the best information available, not enough to account for all the yield loss. Hence, some unknown factor or factors, possibly barley yellow dwarf virus, plus greenbug damage, appears to have caused considerable loss.

At Manhattan the winter wheat nursery was planted on two different dates because of a wet period in October. The early planted nursery had heavy greenbug infestation in the fall and in the spring appeared to be infected by barley yellow dwarf, as measured by yellowing of the plants and reduced yield. The later planted portion did not have heavy greenbug infestation or show these symptoms and the yield was much greater. This was also true of a Pawnee wheat field near Manhattan, a portion of which was planted early and the remainder later after October rains. There were reductions in yield and more shriveled kernels in the early planted portion, as well as plant yellowing in the spring. No loss estimates for wheat were made owing to lack of certain knowledge concerning the causal factors.

A puzzling malady of early planted winter wheat, which also may be barley yellow dwarf, appeared in small patches in several eastern counties during the spring of 1959. Infected plants became very chlorotic and did not elongate normally. In addition to extreme stunting, there was also considerable bud proliferation. Most of the infected plants eventually died. Those that lived usually produced only a few weak culms.

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BARLEY YELLOW DWARF VIRUS ON OATS IN MAINE

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Barley yellow dwarf virus on oats, with its typical red leaf symptoms, has caused concern since its recognition in the experiment station nurseries and on farms during 1955. From 1956-1959 the disease was widespread in Maine and appeared on all varieties in the Uniform Northeastern Oat Variety Tests. Severe infection resulted in blasting.

During 1959, a survey of oats throughout Maine was made to determine the extent of damage. The results are summarized as follows:

1. The English grain aphid (Macrosiphum granarium, Kirby) and the apple grain aphid (Rhopalosiphum fitchii, Fitch) were common in infected fields.
2. All of the oat fields surveyed were adjacent to, or partly surrounded by, forage, especially timothy and clover. This probably furnished a source of early virus infection. In most cases potato fields were also adjacent but did not seem to cause any more or less noticeable red leaf symptoms. Most of the oat crop was grown after potatoes in the rotation.
3. Losses from BYDV are shown in Table 1.

   Infection estimates were based on averages of infected versus non-infected plants in several areas of each field. Distribution of diseased plants was spotty, and some areas were almost completely infected while other areas exhibited few disease symptoms. This was probably due to the early flight pattern of the aphids. The early planted oats (May 10-20) undoubtedly escaped serious infection, since they headed about July 10-15, while the peak of aphid infection was not reached until late July.
4. Infected plants matured earlier than non-infected plants. Some were severely stunted and died.
5. Aphid flights into the oat fields began in late June, and the maximum build-up of aphid populations occurred sometime after July 20th and before August 1st.

Table 1. Estimated BYDV infection losses on two oat varieties, 1959.

Variety	Date planted	Percent plants with BYDV symptoms	Percent yield loss
Clinton 59	May 10-20	5	2
	20-30	30	8
	June 1-10	55	15
Garry	May 10-20	5	2
	20-30	40	10
	June 1-10	50	10

The Maine Agricultural Experiment Station has a project underway to determine the sources of spring infection, vectors responsible, and varietal resistance to BYDV. An extensive testing program was begun in 1959 to inoculate oat varieties and selections with the virus and transplant both inoculated and uninoculated plants to the field to compare performance. There was considerable variability between varieties in symptoms and performance. Results will be published later.

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YELLOW DWARF IN MICHIGAN IN 1959[1]

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Yellow dwarf of oats was coextensive with oat culture in Michigan in 1959. Yellow dwarf has been present to some degree in both spring barley and oat fields in many areas of Michigan every year since 1955. In most of these areas the severity of the disease outbreak was directly related to the area of grass sod fence rows adjacent to oat fields and to the time and amount of movement of the aphid vectors from these sods into the small grain fields.

A check with the station entomologists reveals no reported collections of the greenbug in Michigan in the 1959 growing season. Winged adults of several other aphid species were found in small grain fields from about May 1 through May 24. During this period, there were days with temperatures above 80° F followed by cool nights and several days of cool, wet weather. These conditions favored early flight of aphids into grain fields and rapid colonization of the field occurred after the winged forms arrived. High daytime temperatures occurred on May 2-6, 19-21 and 26-31. The high temperature period from May 26-31 was accompanied by increasing drought. This hot, dry period checked further aphid spread and few aphids were found in fields of oats in Cass County on June 11.

High temperatures and low rainfall in May and June caused oats to mature prematurely and to develop pigments which were difficult to distinguish from the red color caused by yellow dwarf virus. Examination of affected plants for blasting and stunting aided in the confirmation of yellow dwarf damage. Garry oats developed less discoloration, blasting, and stunting than did Clintland, Clintland 60 or Jackson (Table 1). In a demonstration of fertilizer practices in Kent County, Garry oats top-dressed with 20 pounds of nitrogen per acre developed fewer seriously affected plants than did areas of the field not top-dressed.

Table 1. Varietal reaction to the yellow dwarf virus epiphytotic in the rod row oat nursery, Cass County, Michigan, 1959.

Variety	Average percent[a] yellow dwarf damage	Average yield[b] (bushels per acre)
Clintland 60	42	72.0
Jackson	42	78.0
Rodney	25	79.0
Clintland	42	80.0
Simcoe	29	86.0
Eaton	50	86.0
Garry	17	93.0

[a]Average of three randomized replications.
[b]Average of four replications.

The variety of oats grown, date of sowing, level of soil fertility, and availability of soil moisture were important factors in determining the severity of the damage to stands of oats by yellow dwarf virus in Michigan in the 1959 season. Early sown fields of Garry oats which had developed thick stands showed little yellow dwarf damage. Two fields of an unidentified oat variety which were destroyed by yellow dwarf virus in Cass County were planted after the first of May in soils of low fertility. Several other fields of oats which were severely damaged by yellow dwarf in Cass County exhibited thin stands and were planted on soils having a poor fertilizer history.

No significant benefit was demonstrable from treating seed with systemic insecticides prior to sowing. However, both the incidence and the severity of yellow dwarf infection was increased by planting late, and by wide spacing of the grain plants. Under conditions of thin stands and late seeding, losses were as high as 100 percent in Michigan in the 1959 season. However, under conditions of early seeding, good fertility and thicker stands, only trace amounts of damage occurred in the same general farming areas where total losses occurred on late sown fields.

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OCCURRENCE OF BARLEY YELLOW DWARF ON OATS IN MISSISSIPPI, 1959[1]

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Barley yellow dwarf was more widespread and destructive on oats in Mississippi during the last growing season than it has ever been in the past. Estimated losses in grain yields were as high as 30 to 40 percent. No oat field observed was entirely free of the disease, but great variations in the amount of damage were evident. No commercial oat variety appeared to possess resistance, but the severity of the damage was more pronounced on a few varieties. Related differences in resistance of the early, mid-season, and late-maturing oat varieties were not observed. Delair, an early-maturing oat, was badly damaged by the barley yellow dwarf virus, but perhaps not as much as the late-maturing Red Rustproof-type oats. To a large extent, total damage was determined by the vegetative state of the plants at the time of first symptom expression. Yellow dwarf symptoms appeared in the oat nursery at Stoneville in early March. At this time the early-season oat strains had begun to joint, while the late-season ones were still "tillering out." It is probable that this growth differential may be responsible for the smaller reduction in total yields of the earlier varieties than of the later Red Rustproofs. It was unusual to find a completely blasted panicle of an early oat variety, but it was not uncommon to find them readily among the late oat varieties. Not all plants were killed or made unproductive by the virus. Many plants of all oat varieties showed symptoms but matured with no apparent impairments.

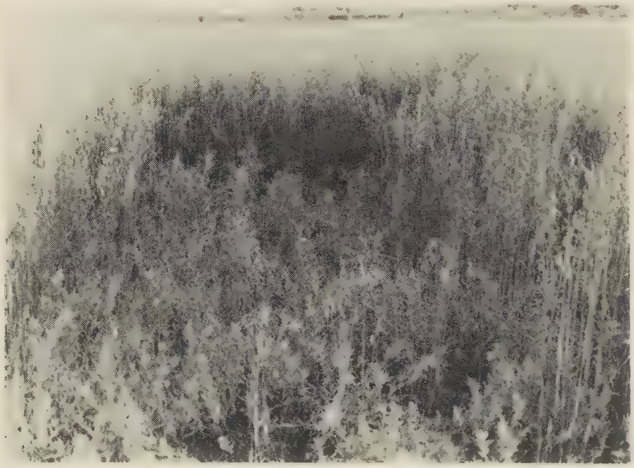

FIGURE 1. A progeny block of space-planted F_2 material heavily damaged by yellow dwarf virus, flanked by progenies showing relatively little injury.

Symptom colorations varied among some oat plants, but these were not reflected in any differences in the expression of the disease. In the Stoneville space-planted F_2 nursery, which was heavily damaged by yellow dwarf (Fig. 1), certain progenies exhibited bright-blue to purple coloration in their leaves. More common, however, was the brilliant-red pigmentation which most progenies exhibited. These two colors were completely absent in some infected strains also in this nursery. On affected plants with this third type of symptom the leaves turned straw color, much like those of a matured plant. Specimens with the three types of symptoms were checked by W. F. Rochow, and the yellow dwarf virus was recovered from all three groups. The different color expressions may well be an interaction of inherent plant characteristics and temperature.

Early in March, plants in the F_2 nursery showing yellow dwarf symptoms were tagged and paired with healthy plants exhibiting similar agronomic characteristics, in an attempt to measure yellow dwarf damage. The unpredictable spread of infection was soon apparent because

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there were no centers of infection. Symptoms appeared almost haphazardly on the space-planted material. Many plants tagged early as resistant became infected as the season advanced. Within the F_2 space-planted nursery, entire progenies were completely eliminated by the virus. Other progenies heavily infected with yellow dwarf contained one or more plants completely free of symptoms. A few progenies were relatively free of the disease except for an occasional plant. While it is possible these plants escaped infection because of the distribution of the vectors, progenies scattered about the nursery which were highly susceptible to the virus had one or more common parents (See list following).

Varieties and Selections Highly Susceptible to Yellow Dwarf at Stoneville, Mississippi, 1959

Arlington: C.I. 4653
Arlington x C.I. 6666: Delta 55158-26
Carolina Red x Clinton^2-Santa Fe: C.I. 7231
[C.I. 3717 (RRPVR) x (Lee-Victoria x Fulwin)] x Clinton^2-Sante Fe: C.I. 7226
C.I. 3720 - Wintok x Santa Fe: Delta 5142-7
C.I. 6936 (LMHJA) x C.I. 7152 (HJLVFBAL): Delta 214
C.I. 6936 (LMHJA) x Mid-South: Delta 5608
C.I. 6936 (LMHJA) x New Nortex-Landhafer: Delta 212
C.I. 7083 (LMHJA) x Delta Red 88: Delta 220
C.I. 7083 (LMHJA) x Delair: Delta X56010
Delair: C.I. 4653
Delair x [(Bonda x Hajira-Joanette) x Santa Fe]: Beltsv. 154
Delta Red 88: C.I. 4220
Fulgrain 55311-5 x C.I. 7145 (LMHJA): Delta X5728
[Haj-Joan x (Lee-Victoria x Fulwin)-(Bond-Anthony)] x Landh: C.I. 7152
Letoria x Clinton^2-Santa Fe (HVR 167): C.I. 7422
(Lee-Victoria x Fulgrain) x (Clinton^2-Santa Fe): Delta 5104-10
Mid-South: C.I. 6977
New Nortex x Landhafer: C.I. 6998
Nortex 107: C.I. 5872
Suregrain: C.I. 7155
Victorgrain 48-93: C.I. 5355
Victorgrain 48-93 x [(Bond-Anthony x Hajira-Joanette) x Santa Fe]: Beltsv. 157
Victorgrain 55284-2 x C.I. 6936 (LMHJA): Delta x 5719

Table 1. Reduction in yields attributed to yellow dwarf virus within the replicated plots of the same entries in the Delta preliminary oat strain tests.

Pedigree	Local or C.I. no.	Average yield of plots (in grams): with yellow dwarf	Average yield of plots (in grams): symptom-less	Yield loss (percent)
(L-V x Fulwin) Cl^2-SF	5104-10	775	990	14
(L-V x Fulwin) Cl^2-SF	CI7237	426	596	29
(CI3717 x CI4316:C18)Cl^2-SF	5312-10	978	1199	18
(CI3717 x CI4316:C18)Cl^2-SF	5105-8-1	423	525	19
(CI3717 x CI4316:C18)Cl^2-SF	5105-8-3	267	498	46
(CI3720 x Wintok:CI4665)SF	5142-7	344	420	18
Victorgrain x Landhafer	5021-6-14	805	1005	20
Delta Red 88	CI4220	331	451	27
Victorgrain (B-A x HJ x SF)	Md. 157	731	990	26
Delair (Minn. Sel:BA x HJ x SF)	Md. 331	292	448	35
Delair (Bonda x HJ-SF)	AB 2647	286	394	27
Delair (Bonda x HJ-SF)	54128-1	433	620	30
Delair (Bonda x HJ-SF)	54128-2	208	361	42
Delair (Bonda x HJ-SF)	54128-3	486	601	19
LMHJA:CI7083 x Delta Red 88	220	717	1001	28
LMHJA:CI6936 x [HJ(LVF)(BA) Land: CI7152]	214	384	502	24
LMHJA:CI6936 x New Nortex-Land CI6994	213	391	602	35
LMHJA:CI6936 x New Nortex-Land CI6994	212	281	473	41

Other widely scattered progenies within the F_2 nursery which showed only an occasional diseased plant in the various areas of the field had either one of two parental lines in common. These lines, X5610: (Unknown x Anderson Selection: C.I. 4837) and 5X567: (Binder: P.I. 173231 x Hein II: C.I. 4837), merit screening as possible sources of resistance.

Low oat yields and test weights reflected the loss caused by yellow dwarf. An attempt was made to measure the loss in yields which could be attributed to yellow dwarf in two oat experiments. In these replicated experiments a record was made of the plots that were infected with yellow dwarf and those that were free of symptoms. Within each entry the average yields of the infected plots were compared with the average yields of the symptomless plots. Percent of reduction was regarded as the loss in yields attributed to the virus. Reductions in yields of 14 to 46 percent were found (Table 1).

The Uniform Winter Barley Nursery and the Mississippi State Barley Test growing contiguous to the oat nursery remained free of visible yellow dwarf symptoms at Stoneville. This was difficult to understand, since aphid infestation was as heavy in the barley plots as in the oat plots. Possibly the particular strain of yellow dwarf virus in this area does not go to barley, or there may have been a different species of aphid on the barley plants. The oat and the barley nurseries were handled in an identical manner and the two barley tests averaged 61.5 bushels per acre, which is unusually high.

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IN COOPERATION WITH THE MISSISSIPPI AGRICULTURAL EXPERIMENT STATION

THE BARLEY YELLOW DWARF VIRUS-BACTERIAL BLIGHT COMPLEX ON OATS IN MISSOURI IN 1959[1]

Dale T. Sechler, J. M. Poehlman, M. D. Whitehead, and O. H. Calvert[2]

Summary

Barley yellow dwarf virus, accompanied by a bacterial blight, damaged oats extensively in Missouri in 1959. The disease followed widespread distribution of greenbugs earlier in the spring. Estimates of leaf area damaged range from 15 to 90 percent with yields ranging from 48 to 9 bushels in different varieties. Correlations of leaf damage to yield, stand, maturity, and test weight are reported.

The barley yellow dwarf virus disease attracted major attention in Missouri for the first time in 1959.

Symptoms of the barley yellow dwarf disease had been observed previously in barley and oats in several different years. Such occurrences of the disease, however, had been spasmodic and limited to small widely scattered areas over nursery plots and farmers' fields. Except for 1949, damage to cereal grains from yellow dwarf in other years was seldom severe enough to be readily identified in mature plants, and very little was reported for the State. In 1949 a heavy "red leaf" infection was observed in oat variety plots on the Southwest Missouri Experiment Field near Pierce City; this was the only occasion, prior to 1959, that the disease was observed in sufficient intensity to record varietal reactions.

During the first few days of May in 1959 a heavy build-up of aphids was observed in the oat nurseries at Columbia. Survey entomologists had been reporting heavy greenbug infestations across southern Missouri during the previous 2-week period[3]. By May 5 visible damage, which appeared at first to be from aphid feeding, could be seen on the oat plants. This was followed by the appearance of yellow-green and yellow-orange to red coloration of the leaf blades, which gradually spread to the leaf sheaths. At this time the oat plants were beginning to joint. Examination of leaf tissue also revealed the presence of a bacterial exudate on the infected leaves (Fig. 1). Since the bacterial infection was general, no comparison could be made with bacteria-free plantings, which complicated any effort to determine the damage incited by either the virus or bacteria alone. Leaf-tip tissue was destroyed to a greater degree than would have been expected from virus alone.

Oats headed at Columbia largely between May 30 and June 5. By this time differences in varietal reaction to the disease could be readily observed. Varieties most severely damaged showed almost complete discoloration -- with many leaves or portions of the leaves dead, a marked reduction in tillering, dwarfing of secondary tillers and even the main tiller in severely affected varieties, and partial to almost complete blasting of spikelets. Differences in varietal reaction were observed as differences in the proportion of discolored leaves, the number and degree of dwarfing of the tillers, and the proportion of blasted spikelets. The gross appearance of the plots left no doubt that yield differences between the more resistant and the more susceptible varieties would be large. The disease did not appear in small spots -- as was frequently reported and observed here in other years, but was spread uniformly over all of the experiment field on which oats were planted. Varietal differences were consistent from block to block and between drill and nursery plots. Spaced plants and plots with thin stands were more severely damaged than thickly seeded plots. This appears to be a function of the aphid feeding, that is, aphids were present in greater numbers on plants in thinly spaced planting.

Visual estimates of leaf damage and yields of varieties and strains grown in drill plots are shown in Table 1. Leaf damage was estimated as percentage of leaf area killed or discolored. The data are from 1/40-acre unreplicated plots, but leaf damage and yield were quite similar in plots of standard varieties grown at each end of the block. Correlation coefficients

[1] Approved by the Director of the Missouri Agricultural Experiment Station as Journal Article No. 2083.

[2] Instructor, Professor, Associate Professor, and Assistant Professor in Field Crops, respectively.

[3] See the following article by Thomas and Munson on "The occurrence of aphids on small grains in Missouri during the spring of 1959."

Table 1. Leaf damage and yield of oat varieties grown in drill plots at Columbia in 1959.

Variety	Leaf area damaged (percent)	Yield (bushel/acre)
CI 7448 [(Victoria x Hajira-Banner) x (Victory x Hajira-Ajax)] x Mo. 0-205[2]	15	48.4
CI 7129 Early Clinton (Okla. sel.)	15	33.8
Newton	30	33.8
CI 7396 Fulton-Clinton x Mo. 0-205	35	38.3
CI 7447 [(Victoria x Hajira-Banner) x (Victory x Hajira-Ajax)] x Mo. 0-205[2]	35	33.8
CI 7267 Clintland x (Gary x Hawkeye-Victoria)	35	37.1
Andrew	40	25.9
Mo. 0-205	45	30.4
CI 7394 Early Clinton (Mo. sel.) x Mo. 0-205	45	36.0
CI 7154 Markton-Rainbow x D69-Bond	45	28.1
Burnett	50	24.8
CI 7395 Early Clinton (Mo. sel.) x Mo. 0-205	50	30.4
CI 7379 Osage x [(Bonda x Hajira-Joanette) x Sante Fe]	50	28.1
Goodfield	55	15.8
Macon	60	28.1
Minhafer	60	13.5
CI 7272 Macon x [(Victoria x Hajira-Banner) x (Victory x Hajira-Ajax)]	65	18.0
Nehawka	75	20.3
Clintland	90	10.1
Clintland 60	90	9.0
CI 7235 Rodney x Landhafer-Forvic	90	12.4

Correlation coefficient (Leaf damage versus yield) $r = -.871 \pm .087$
Regression coefficient (Yield on leaf damage) $b = -.438$

Table 2. A -- Correlation coefficients (r) for percent of leaf area damaged versus yield, percent stand, date of maturity, and test weight in four oat tests at Columbia, Missouri in 1959.

Test number	Number of strains	Percent leaf damage versus: yield	percent stand	time of maturity	test weight
1	31	$-.741 \pm .124$	$-.328 \pm .176$	$+.724 \pm .128$	$-.608 \pm .148$
2	30	$-.897 \pm .083$	$-.652 \pm .143$	$+.575 \pm .154$	$+.316 \pm .179$
3	28	$-.635 \pm .151$	$-.209 \pm .192$	$+.629 \pm .152$	$+.436 \pm .177$
5	38	$-.891 \pm .075$	$-.218 \pm .162$	$+.276 \pm .155$	$+.157 \pm .164$

Level of significance (5%): 31 entries=.349, 30 entries=.355, 28 entries=.367, 38 entries=.325.

B -- Regression coefficients (b) for percent of leaf area damaged on yield, percent stand, date of maturity, and test weight in four oat tests at Columbia, Missouri in 1959.

Test number	Percent leaf damage on: yield	percent stand	time of maturity	test weight
1	- .986	- .481	+.133	-.061
2	-1.017	-1.125	+.097	+.018
3	- .213	- .609	+.211	+.320
5	-1.015	- .455	+.065	-.017

FIGURE 1. Oat leaves damaged by the virus-bacterial complex. A reddish brown leaf streaking developed, accompanied by a bacterial exudate which may be observed as white areas in the photograph.

FIGURE 2. Representative plants from oats varieties grown in drill plots at Columbia in 1959. The varieties and the percent leaf damage are (from left to right): Clintland 60, 90%; CI 7192, Early Clinton (Okla.) 15%; Mo. 0-205, 45%; Mo. 04796, 15%; CI 7235, Rodney-Landhafer-Forvic, 90%.

for leaf damage versus yield for 34 strains within the block was -.871. The regression of yield on intensity of leaf damage was -.483. Rust and other diseases were not apparent. Typical plants from five varieties are shown in Figure 2.

Leaf damage was estimated also on 127 varieties and strains grown in four replicated yield tests. Correlation coefficients and regression coefficients were calculated for leaf damage versus yield, stand, maturity, and test weight (Table 2). Highly significant negative correlations were obtained for leaf damage and yield in each test. Correlations for leaf damage and percent stands were calculated because poor stands had been obtained with some varieties in each test and observations indicated greater aphid feeding on thinly spaced plants. However, a significant negative correlation was obtained in only one of the four tests. Published reports indicate that early maturity is important to escape the disease. For this reason, correlations of leaf damage versus maturity were calculated and significant positive correlations were obtained in three tests. A significant negative correlation was obtained for leaf damage versus test weight in one test and a significant positive correlation in one test. Close inspection of the data indicates that considerable variation in test weight between varieties occurs irrespective of their reaction to yellow dwarf.

Damage in oat fields over the State was extensive. The State loss was estimated at 37 percent, with estimates ranging from 2 to 70 percent in different areas.

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THE OCCURRENCE OF APHIDS ON SMALL GRAINS IN MISSOURI DURING THE SPRING OF 1959

George W. Thomas[1] and Ralph E. Munson[2]

The greenbug, Toxoptera graminum (Rondani), outbreak on small grains and orchard grass attracted much attention chiefly through its dissemination of the barley yellow dwarf disease of barley and oats.

Species of aphids taken from small grains during the spring of 1959 were as follows:

Aphid species	Host
Greenbug, Toxoptera graminum (Rondani)	Barley, wheat, oats, orchard grass, and rye
English grain aphid, Macrosiphum granarium (Kirby)	Wheat, barley, and rye
Apple grain aphid, Rhopalosiphum fitchii (Sanderson)	Wheat and barley

The only species of aphid taken from oats was the greenbug, Toxoptera graminum.

A brief history of the greenbug build-up and spread through the State in 1959 follows.

The first record of greenbug occurrence was taken from barley and wheat in the extreme southwest area during the first week of April. Counts ranged from 0 to 2 per linear foot of drillrow.

By April 18, there had been a slight increase in greenbug numbers on barley and wheat and moderate to heavy numbers were present on orchard grass as far north and east as Greene and Lawrence counties.

By April 25, populations had rapidly increased in the southwest area. Counts ranged from 2 to 150 per linear foot of wheat drillrow and 20 to 300 per foot of barley drillrow. Spots within orchard grass fields were being destroyed and some spraying operations had begun. Winged adult aphids averaged 1 per square yard of wheat in the central area (Boone County).

By May 2, the heavy north, northeast migration was well underway. Counts in the southwest area ranged from 500 to 1000 per square foot of orchard grass and 15 to 250 per foot of barley drillrow. The majority of these populations were developing wings. Although there are no data to confirm this, the authors believe that this was the week in which spring oats in the northern third of the State became uniformly infested with winged adults.

By May 9, populations had declined rapidly in the southwest area and were increasing rapidly in the northern half of the State on oats and late seeded wheat.

By May 16, very heavy populations and damage were occurring on oats and late seeded wheat in the northeast, north-central and the northern half of the central area and were increasing in the northwest area. Counts ranged from 100 to 5000 per foot of oat drillrow, 50 to 1000 per foot of barley drillrow and 40 to 800 per foot of wheat drillrow.

By May 22, populations in oats ranged from 6 to 1000 per foot of oat drillrow in the northwest area. Populations over the remainder of the State had declined rapidly, due to predators, parasites and diseases.

By June 6, greenbug populations were practically non-existent throughout the State. Very heavy incidence of barley yellow dwarf was occurring throughout most of the counties north of the Missouri River.

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YELLOW DWARF VIRUS IN MONTANA IN 1959

E. L. Sharp

In 1959 yellow dwarf virus was most prevalent on barley, but was also found on oats in localized areas.

Barley in several counties of the State was infected with the disease, but most damage was probably caused in Gallatin, Park, Broadwater and Jefferson counties. Many barley fields were attacked quite late in the season, so losses were not extensive. A few later planted fields were observed that suffered a 50 percent loss as a result of the disease. The vector was identified by the State Entomologist as the corn aphid. This aphid preferred feeding on barley as compared with wheat and oats. Adjoining fields of wheat and oats were often non-infested and apparently non-affected.

The yellow dwarf virus on oats was observed in Ravalli, Missoula, and Teton counties. Losses were generally not extensive, but some fields were heavily damaged. As high as 50 percent losses were estimated in Ravalli County. In the Fairfield bench area of Teton County yields ranged from 35 to 50 bushels per acre. Ordinarily some fields in this area yield around 100 bushels per acre.

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DIFFERENTIAL TRANSMISSION OF BARLEY YELLOW DWARF VIRUS FROM FIELD SAMPLES BY FOUR APHID SPECIES[1]

W. F. Rochow[2]

Summary

Barley yellow dwarf virus (BYDV) was recovered from 109 of 137 oat samples (from 13 States) and from 18 of 23 barley samples (from 5 States) tested for suspected infection by the virus. Comparative transmission tests from each sample were made by means of apple grain, English grain, and corn leaf aphids, and greenbugs. BYDV was recovered from 68 samples by English grain aphids only, from 14 by apple grain aphids only, and from 25 by both apple grain and English grain aphids. It was recovered from 12 samples by corn leaf aphids only and by corn leaf aphids from 7 samples from which other species also transmitted virus. BYDV was transmitted by greenbugs from 2 samples, one of which also was positive with corn leaf aphids. Recovery of virus by the different aphids frequently varied with the area in which the samples had been collected. Predominant transmission from samples from Mississippi, Texas, Pennsylvania, and New York was by English grain aphids only. Apple grain aphids were most effective in transmission from samples from California and Illinois, whereas corn leaf aphids were most effective only for samples from Gainesville, Florida.

Direct comparative tests on transmission of barley yellow dwarf virus (BYDV) by apple grain (AG) and by English grain (EG) aphids have been made in Washington and in New York. In Washington virus was generally recovered by both aphids (2, 8), but in New York the virus was usually recovered only by EG aphids (4, 5). Since the AG aphid has been used effectively for transmission of this virus in other areas of the United States (1, 3, 7), it appeared that strains of BYDV in New York might be different from those common in other areas. Current ideas on vector specificity of strains of BYDV (5, 6, 8) emphasize the importance of knowledge about occurrence of strains of this virus. One purpose of the present study was to determine whether the EG-transmitted strain of virus is common only in one section of the United States, as available data indicate.

Virus had been recovered by AG or EG aphids from all but 5 of the 80 New York samples tested previously in this laboratory (4, 5). One possible explanation for failure to recover virus from these 5 samples is that they were infected with vector-specific strains of BYDV that would have been transmitted only by aphids different from the two used (5). A second purpose of the present study was to compare the action of two additional aphid vectors with that of the two species used previously in the transmission of BYDV from field samples.

MATERIALS AND METHODS

The four aphid species used in this work have been shown by Oswald and Houston (3) to be vectors of BYDV. They were as follows: 1) apple grain (AG) aphids (*Rhopalosiphum fitchii* (Sand.), these aphids have been identified as *R. fitchii* by several entomologists but one worker has identified them as *R. padi* L.); 2) English grain (EG) aphids (*Macrosiphum granarium* (Kirby)); 3) corn leaf (CL) aphids (*Rhopalosiphum maidis* (Fitch)); and 4) greenbugs (*Toxoptera graminum* (Rond.)). AG and EG aphids were those used previously (4, 5). CL aphids were collected in Ithaca, New York, in the fall of 1958. Greenbugs were supplied by H. H. Luke and A. N. Tissot from Gainesville, Florida in February 1959. Virus-free stock colonies of all four species were started weekly from newly emerged nymphs and maintained

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[2]Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Assistant Professor, Cornell University. Grateful acknowledgment is made to Reidar Haavie, Anna Greenmun, Maureen Quinn, and Glenn Benjamin for part-time assistance and to the cooperators listed separately who collected most of the samples.

according to precautions described previously (4, 5). Although all aphid colonies have remained virus free, some aphids from each colony used always were tested as nonviruliferous controls.

Samples tested were either collected by the writer (for New York) or sent between moist blotters by one of the following: H. H. Luke (Florida), D. D. Morey (Georgia), T. T. Hebert (North Carolina), P. G. Rothman (Mississippi), H. C. Murphy and M. C. Futrell (Texas), H. C. Murphy and C. A. Suneson (California), H. C. Murphy and J. M. Poehlman (Missouri), Henry Jedlinski (Illinois), J. A. Browning (Iowa), K. D. Fezer (Minnesota), D. C. Arny (Wisconsin), and B. F. Coon and R. D. Schein (Pennsylvania). Samples received from H. C. Murphy from South Dakota and from J. T. Slykhuis from Ontario had deteriorated in the mail and were not tested. Tests were made on 137 oat samples and on 23 barley samples.

Each sample consisted of a single leaf collected in the field from a plant believed to be infected by BYDV. Since only one leaf was collected from a plant, each test represents a different field plant. Each leaf that was still turgid when received was cut into four longitudinal sections. Each section was placed in a separate dish containing moistened filter paper and infested with AG, EG, or CL aphids, or greenbugs (except for some Florida samples) as described previously (4) except for use of plastic dishes with tight-fitting covers instead of Petri dishes. The leaf sections were incubated at 15° C for an acquisition feeding period of 24 to 48 hours. A comparable group of aphids from each colony used was placed in a separate dish on healthy seedlings to serve as a nonviruliferous aphid control.

At the end of the acquisition feeding period the dishes were taken to the greenhouse, where aphids from each dish were transferred to three seedlings of California Red oats (C.I. 1026) in groups of about 10 aphids per seedling. The test seedlings had been grown in steam-sterilized soil in 4-inch pots. Most of the aphids used were mature apterous females, but often other forms were included in each group. Test seedlings were caged by means of pot cages during a 3-day inoculation test feeding period. Then all aphids were killed by fumigation with lindane in a closed chamber. Plants were next placed on a greenhouse bench under supplemental illumination and were observed at intervals for at least 4 weeks. The reactions of all three plants in each pot generally were the same, but results were considered positive if any one of the three plants developed symptoms of infection by BYDV.

RESULTS AND CONCLUSIONS

BYDV was recovered from 109 of the 137 oat samples tested (Table 1). The virus was transmitted by EG aphids only from 36 New York samples and from 27 other samples from nine different States. Virus was recovered by EG aphids from 24 additional samples from which one or more other aphid species also transmitted. That is, EG aphids transmitted BYDV from a total of 87 of the 109 oat samples from which the virus was recovered. BYDV was transmitted by AG aphids, either alone or in addition to other aphid species, from 33 samples. It was transmitted by CL aphids from 16 oat samples. In only two cases was the virus recovered by greenbugs.

When BYDV was transmitted from a leaf by more than one aphid species, the relative severity of disease caused by the isolate transmitted by each aphid species was generally the same. There was some variation among isolates in severity of disease caused, but this variation was not related to the aphid species which had transmitted.

Although very few samples were tested from many areas, it is clear that samples from New York were not the only ones from which predominant transmission was by EG aphids only (Table 1). Most of the transmissions from samples from Mississippi, Texas, Pennsylvania, and New York were by EG aphids only. Four of these EG-isolates from States other than New York were tested in an additional transfer by means of the four aphids. Since all four virus isolates again were transmitted only by EG aphids, they appear to be similar to the EG-specific strain obtained from New York in 1957 (4, 5).

This EG-transmission was in contrast to that from samples collected in California and Illinois, from which all recoveries were by AG aphids, either alone or in addition to other species (Table 1). Samples from Florida were still different. Thirteen samples from Gainesville, Florida were tested with CL aphids; virus was recovered from 9 of them. Only occasional recoveries by CL aphids were obtained from samples from other areas (Table 1). Moreover, samples from Quincy, Florida appeared to be different from those from Gainesville, since virus was recovered from all three Quincy samples by EG aphids only.

Transmissions by CL aphids were of special interest since some of them support the idea that other vector-specific strains of BYDV exist. Virus was recovered by CL aphids from 10

Table 1. Comparisons of action of apple grain (AG), English grain (EG), and corn leaf (CL) aphids, and greenbugs (GB) in virus transmission from field samples of oats with symptoms of infection by barley yellow dwarf virus (BYDV).

Source of sample	Number of leaves from which BYDV was transmitted, over number of leaves tested	Grouping of BYDV-positive leaves according to transmission (+) or nontransmission (-) by each of the four aphid species: Number of leaves in group	Transmission pattern: AG	EG	CL	GB
Florida[a]	13/23	7	-	-	+	-
		1	-	-	-	+
		1	-	-	+	+
		1	+	+	+	-
		3[b]	-	+	-	-
Georgia	2/2	2	-	+	-	-
North Carolina	2/2	1	-	+	-	-
		1	+	+	-	-
Mississippi	8/12	5	-	+	-	-
		3	+	+	-	-
Texas	6/8	5	-	+	-	-
		1	+	+	-	-
California	13/17	7	+	-	-	-
		5	+	+	-	-
		1	+	+	+	-
Missouri	1/3	1	-	+	-	-
Illinois	4/5	2	+	+	+	-
		1	+	+	-	-
		1	+	-	-	-
Iowa	3/4	1	+	+	-	-
		1	-	-	+	-
		1	-	+	-	-
Minnesota	4/4	2	+	+	-	-
		1	-	+	+	-
		1	-	+	-	-
Wisconsin	1/4	1	-	-	+	-
Pennsylvania	10/10	8	-	+	-	-
		1	+	-	-	-
		1	+	+	-	-
New York	42/43	36	-	+	-	-
		4	+	+	-	-
		1	+	-	-	-
		1	-	-	+	-

[a]All Florida samples were tested with EG aphids and greenbugs. Only 18 samples were tested with AG and only 16 with CL aphids.

[b]These three samples were from Quincy; the others were from Gainesville, Florida.

oat samples that were negative on the basis of tests with the other aphids (Table 1). Seven of these samples were from Gainesville, Florida and one each was from Iowa, Wisconsin, and New York. In 1958 the writer had tested 13 samples sent from Gainesville by H. H. Luke; all were negative, but the tests had been made only with AG and EG aphids. Preliminary tests with some of the CL-transmitted isolates suggest that a degree of vector-specificity exists for these isolates, as it does for some AG- and EG-transmitted ones (5).

Results from the barley samples (Table 2) were similar to those from oats. BYDV was recovered from 18 of the 23 samples tested. All transmissions from California samples were by AG aphids. EG aphids were most effective for New York samples. In two cases virus was recovered only by CL aphids.

Table 2. Comparisons of action of apple grain (AG), English grain (EG), and corn leaf (CL) aphids, and greenbugs (GB) in virus transmission from field samples of barley with symptoms of infection by barley yellow dwarf virus (BYDV).

Source of sample	Number of leaves from which BYDV was transmitted, over number of leaves tested	Grouping of BYDV-positive leaves according to transmission (+) or nontransmission (-) by each of the four aphid species				
		Number of leaves in group	Transmission pattern			
			AG	EG	CL	GB
Texas	1/2	1	+	-	-	-
California	4/6	3	+	+	-	-
		1	+	-	-	-
Pennsylvania	1/2	1	+	-	-	-
New York	7/8	5	-	+	-	-
		1	+	+	-	-
		1	-	-	+	-
Wisconsin	5/5	2	+	+	-	-
		1	+	+	+	-
		1	+	-	-	-
		1	-	-	+	-

In all tests plants infested with aphids as nonviruliferous controls remained healthy.

It should be emphasized that these are data only on recovery of BYDV from detached-leaf field samples and that they do not necessarily have any bearing on the relative importance of the different aphids as vectors of the virus in nature. The results do suggest, however, that the important aphid vector of one area may be different from that of another area, and the results reported here may be of value as a guide to field studies on the relative importance of different aphids as vectors of BYDV in nature. These results also emphasize the problems involved in interpreting results of negative transmission tests when only one or two aphid species are used.

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BARLEY YELLOW DWARF VIRUS DISEASE OF OATS IN NEW YORK IN 1959[1]

W. F. Rochow and E. D. Jones[2]

This was not an unusual year in New York for infection of oats by barley yellow dwarf virus. As in previous years, infected plants were found in all oat fields examined during the season. Infection was present only in trace amounts in most fields early in the season. The amount of infection increased during the season; the majority of infections occurred late and had less effect on yield than did the early ones.

In the Ithaca area infected oat plants were first observed late in May. English grain aphids were commonly observed in oat fields; they were particularly abundant during the middle of June. Other aphid species were not found, but no serious attempts were made to find them. For the second year, progeny of some Cornell oat crosses (Craig x Alamo) showed resistance to natural infection.

Perhaps the most significant observation from this area is that in 4 years not a single field of oats beyond the seedling stage has been found to be free of this disease.

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YELLOW DWARF OF CEREALS IN NORTH CAROLINA IN 1959

T. T. Hebert, D. M. Kline, and R. W. Toler[1]

Yellow dwarf was widespread on small grains in North Carolina in 1959. It was observed in all parts of the State, but was more prevalent in the Coastal Plains and Piedmont than in the Mountains. In some fields only a few scattered infected plants were observed, while in other fields infection approached 100 percent. Symptoms on oats were much more pronounced than on wheat or barley. A reddening of the leaves was the principal symptom on oats. Only a small percentage of wheat and barley plants showed yellowing of the leaf tips even in nurseries where a high percentage of oat plants had red leaves.

APHID VECTORS

Since the yellow dwarf virus is transmitted by aphids, a limited survey was made to determine the relative prevalence of aphid species on small grains in North Carolina. In fall collections the greenbug, Toxoptera graminum (Rondani)[2], was the predominant species. This aphid was found in practically every field visited and was causing considerable damage in a number of fields. Rhopalosiphum padi (Linn.) (Kaltenbach) was present in about 10 percent of the fields visited and was collected from wheat, oats, barley, and rye. The corn leaf aphid, Rhopalosiphum maidis (Fitch), was found in about 20 percent of the barley fields, but this aphid was not found on wheat, oats, or rye. The apple grain aphid, Rhopalosiphum fitchii (Sanderson), was observed in only one field. During the winter the aphid population decreased to a very low level. However, by late February and early March aphids were more numerous. Collections made in March, April, and May were predominantly the English grain aphid, Macrosiphum granarium (Kirby). Although this aphid was found in practically all fields visited, usually only a small percentage of the plants were infested. The prevalence of R. padi and the corn leaf aphid was about the same in the spring as in the fall. The greenbug was found in only two fields in the spring. No other known vector of the barley yellow dwarf virus was found.

TRANSMISSION TESTS

Although no yellow dwarf symptoms were apparent in November, aphids were collected in fields and tested in the greenhouse to determine if they were viruliferous. Fourteen collections of greenbugs, two collections each of corn leaf aphids and R. padi, and one collection of apple grain aphids were tested and found to be non-infective.

Ten to twenty seedlings on which aphids were feeding were collected in the fall in each of ten fields, transplanted to the greenhouse, and observed for symptoms of yellow dwarf. Only a single plant developed symptoms of yellow dwarf. Greenbugs were feeding on this plant at the time it was collected; however, other aphids may have fed on it previously. These limited tests indicate that only a small percentage of the plants in fields were infected with yellow dwarf in the fall.

In the spring aphids were collected in fields in which plants were showing symptoms of yellow dwarf. These aphids were allowed to feed on apparently diseased plants collected from the same field and then on test plants. In a few cases virus-free aphids were used to check for the presence of the yellow dwarf virus. The barley yellow dwarf virus was transmitted from plants from 8 of 10 locations with the English grain aphid, from 4 of 5 locations with R. padi, and from 1 of 3 locations with the corn leaf aphid. A single test with the greenbug failed to transmit the virus.

VARIETAL REACTIONS TO YELLOW DWARF

A rather uniform infection of yellow dwarf occurred in a planting of the Uniform Central Area Oat Nursery at Clayton, North Carolina, and a somewhat less uniform infection occurred

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[2]Grateful acknowledgment is made to Mr. A. T. Olive, Department of Entomology, North Carolina State College for identification of the aphids.

Table 1. Reaction of oat varieties and selections to yellow dwarf in the field.

C. I. number[a]	Variety or selection	Disease rating[b] Clayton April 29, 1959	Salisbury May 13, 1959
7175	Victorgrain 48-93	3.0	1.5
6977	Midsouth	2.9	1.5
7239	Vict. x (Bonda x H. J. x S.F.) Md. 116	2.1	2.0
7403	Coker's 58-7	2.1	2.0
1815	Appler	3.0	3.5
7421	Coker's 57-20	1.5	1.5
7418	Luke's H. V. Res. Vict. Fla. 284-2	2.5	1.5
7415	Luke's H. V. Res. Vict. Fla. 303-9	2.5	2.0
7229	Moregrain	2.0	2.5
7294	Coker's 57-11	2.6	3.0
3531	Fultex	2.1	2.5
7304	(Vict. x Coker's 52-22) x 6671	1.8	2.0
7225	(L-V x Fulwin) x Bonda	1.9	1.5
6994	Tennex x (Victoria-H. B.)	2.6	2.0
7143	Tennex x (Victoria-H. B.)	2.8	2.5
Check	Lee	1.4	1.0
7231	C. Red x (Cl^2 x S.F.)	2.1	3.5
6571	Bronco	1.9	1.5
4660	Mustang	2.1	4.0
7136	(L-V x F) x (F-A) x Land.	2.1	3.0
7307	(Atl. x (Cl^2 -S.F.)) x Imp. Garry Md. 370	1.5	1.0
7308	Win. x (Cl^2 -S.F.) x Imp. Garry Md. 2950	1.3	1.0
7309	Win. x (Cl^2 -S.F.) x Imp. Garry Md. 2725	1.4	1.5
4657	Arlington	1.3	1.0
7311	Arl. x ((B-H. J.) x S.F.) Md. 333	1.4	2.0
1815	Appler	3.9	4.0
7220	Arl. (Win. x (Cl^2 -S.F.)) Md. 310	1.3	1.0
7413	Arl. (Win. x (Cl^2 -S.F.)) Md. 232	1.5	2.0
7416	Arl. (Win. x (Cl^2 -S.F.)) Md. 222	1.3	1.5
7417	Arl. (Win. x (Cl^2 -S.F.)) Md. 251	1.9	1.5

[a] C. I. refers to the accession number of the Cereal Crops Research Branch, Crops Research Division.
[b] Relative degree of leaf reddening; 1 = little or no reddening, 4 = maximum reddening. Averages of four replications at Clayton and two replications at Salisbury.

Table 2. Reaction of winter barley varieties and selections to inoculation with the barley yellow dwarf virus.

C. I. number	Variety or selection	Reaction to yellow dwarf[a] Test 1 February 17, 1959	Test 2 April 13, 1959
6728	Wong	7	9
8067	Hudson	7	9
8062	Colonial 2	5	5
9170	Davie	10	10
7576	Cordova	8	5
9564	Tex. 10-47-84	9	9
9565	Tex. 10-47-136	8	9
7524	Harbine	9	9
9174	Rogers	9	10
9566	Pace	5	5
9569	Oma	4	4
9570	Kenate	5	8
7574	Kenbar	6	8
8107	Marconee	9	9
8065	Calhoun M450-4	10	10
10298	N.C. 954	10	10
9517	Dayton	6	9

[a] Based on stunting; 1 = no apparent stunting; 10 = very severe stunting.

in this group of varieties at Salisbury, North Carolina. Ratings were made on the relative amount of reddening of the varieties at each location (Table 1). Appler appeared to be the most susceptible variety of this group. Arlington and Lee showed a relatively small amount of leaf discoloration. Several experimental lines also appeared to have considerable tolerance.

Barley varieties from the Uniform Winter Barley Nursery of Semihardy Varieties were inoculated in the three-leaf stage in the greenhouse by allowing viruliferous R. padi aphids to feed on them for 3 days. The aphids were then killed, and the plants were grown in the greenhouse for observation. The most conspicuous symptom was stunting as compared with uninoculated plants of the same variety and only a small amount of yellowing developed. The varieties were rated for degree of stunting about 6 weeks after inoculation (Table 2). Oma, Pace, and Colonial 2 appeared to have some tolerance to yellow dwarf in these tests, whereas Davie, Calhoun M450-4 and N.C. 954 appeared to be very susceptible. In the field, however, Davie appeared to be only slightly more susceptible than Colonial, although neither variety was very severely affected by yellow dwarf.

Field observations indicated that there was little difference in reaction to yellow dwarf among the wheat varieties commonly grown in North Carolina. None of the varieties appeared to be greatly affected in 1959. When inoculated in the seedling stage in the greenhouse, Anderson showed somewhat more leaf yellowing than did Atlas 66, Atlas 50, Taylor 49, Knox, Seneca, and Thorne. Although moderate stunting was observed, these varieties differed little in stunting.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION, RALEIGH AND CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

BARLEY YELLOW DWARF ON OATS IN OHIO

Dale A. Ray[1]

Symptoms of barley yellow dwarf have been observed on oats in farmers' fields in central and southern Ohio and in the experimental-plot nurseries at Columbus for several years. The leaves on oat plants in localized areas in fields showed varying degrees of chlorosis, from a water-soaked colorless condition through shades of yellow to deep red. On early inspection, nutrient deficiencies were suspected. The apparent damage in reduction of crop yield was not usually significant, owing to the limited areas of attack in the fields.

The first indication of the potential for serious damage to the oat crop by a high incidence of the disease was provided in a study at Columbus in 1958 on the influence of date of seeding on oat yields. Over 100 entries of spring oats were seeded in single five-foot rows on April 4 and May 8. Little infection was observed on any entries in the early planting, but the entire seeding in May was severely damaged with yellow dwarf and very little seed was harvested on maturity. The effect of the disease appeared to be most critical in direct relation with the relative maturity ratings of the entries. Computation of reduction in yield due to barley yellow dwarf was not possible since infection was confounded with date of seeding and no entries could be used as checks since all were damaged.

The incidence of yellow dwarf on oats was more widespread in occurrence in 1959. The reduction in yield was indirectly related to the stage of plant development when the symptoms first occurred. Local areas in fields or entire fields in central Ohio which were attacked early in the growing season and several fields of late-maturing varieties, such as Rodney and Garry, gave only limited production. Estimates of 0 to 75 percent reduction in yield of oats from yellow dwarf infection were reported from specific fields. Areas of infection in fields appeared to spread in a circular pattern from a localized center of initial attack.

Observational data on the extent of damage by the disease were recorded for all rod-row nursery plots at Columbus. Incidence of yellow dwarf was very general and no entry appeared immune. Local areas showed severe stunting of growth but there did not appear to be any relation between spread of the disease and the degree of susceptibility of the entries.

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BARLEY YELLOW DWARF ON OATS IN OREGON[1]

W. B. Raymer and Wilson H. Foote[2]

Cereal yellow dwarf, first identified in Oregon in 1954, did not cause serious losses until 1957. Initially the virus appeared to be limited to the Willamette Valley of western Oregon, but in 1958 it was present in all of the counties along the Columbia River east of the Cascade Range and in the northeastern section of the State as far as the Idaho border. Although some losses to late-seeded spring grains occurred in the eastern part of the State in 1958, major damage has been confined to western Oregon. Losses in small grains due to yellow dwarf have increased yearly until 1959, when an estimated 20 to 25 percent of the total cereal crop in the Willamette Valley was destroyed.

Three circumstances certainly contribute to the continued seriousness of yellow dwarf in Oregon: 1) Large acreages of both cultivated and native grasses in western Oregon are susceptible to the yellow dwarf virus and act as reservoirs for the disease.

2) Rainfall in the Willamette Valley ranges between 40 and 50 inches annually, with appreciable amounts in the spring months. In most years, when the soil has dried sufficiently for spring planting, aphids are already plentiful and active. These aphids carry the virus from perennial grasses into the grain fields and infect the young plants in the 2- to 3-leaf stage or earlier. This early infection stunts both the foliage and root systems. The stunted root systems cause infected plants to suffer severe damage when moisture becomes scarce during the warm dry period in late spring and early summer.

3) The usually mild winters in the Willamette Valley appear to permit larger numbers of aphids to survive than is the case east of the Cascade Range where winter temperatures are much lower.

Loss estimates were first obtained in 1957 through a series of surveys made by the senior author. In 1958 and 1959 county agents were asked to conduct surveys in each of the 10 Willamette Valley counties. Farmers, warehousemen, field men and others in the grain trade were consulted on these surveys and the results adjusted by the county agents on the basis of their knowledge of farming practices and other conditions which affected the crop. A definite attempt was made to eliminate loss factors not directly connected with yellow dwarf.

By 1959 fairly accurate yield data were available for the 1957 and 1958 crops from the crop reporting service of Oregon State College and the United States Department of Agriculture. Preliminary estimates were available for the 1959 crop. Yield data for oats were available only as a figure representing the entire State. Since about 70 percent of the oat crop in the State (or about 200,000 acres) is grown in the Willamette Valley, the total yield for the State should reflect the losses to yellow dwarf in western Oregon. A "normal yield per acre" for the State was computed by averaging the yield per acre for the years 1954-56 as reported in commodity data sheets by the Oregon Crop and Livestock Reporting Service. A total potential yield for the State was then determined for each year by multiplying the acreage by the "normal yield per acre." The decrease in yield due to yellow dwarf as determined by the surveys was then computed as a percentage of the total potential yield. To compensate for the fact that the Willamette Valley represented only 70 percent of the total oat crop, the estimates were multiplied by a factor of 0.70. For example, the 1958 loss was computed as follows:

Total potential yield --

311,000 acres x 0.601 tons ("normal yield per acre") = 186,911 tons

Loss in the Willamette Valley estimated at 10 percent --

0.10 x 0.7 x 186,911 = 13,083 ton loss

13,083 x $41.90 (average seasonal price) = $556,976

This procedure was employed in making the yield loss estimates from the survey material, as shown in Table 1.

To check the estimates from surveys, the total loss in oat production in the State was computed from the commodity data sheets. These losses were again based on a "normal yield per acre" equal to the average for 1954-56. These figures represented the total loss to the State without breakdown according to area or to cause. There was no attempt to separate the causes of this total decrease in yield, and such factors as a moderate outbreak of stem rust in the Klamath Falls area in 1958 were ignored. Losses from yellow dwarf should always be less than the total losses for the State. A comparison of these two types of estimates is presented in Table 1.

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[1] Technical Paper No. 1276, Oregon Agricultural Experiment Station.

[2] Respectively, Assistant Professor, Department of Botany and Plant Pathology, and Professor, Department of Farm Crops, Oregon State College.

Table 1. Comparison of losses due to yellow dwarf of oats in the Willamette Valley with total losses in Oregon.

Year	Percent loss		Loss in tons		Loss in dollars	
	WV[a]	TL[b]	WV	TL	WV	TL
1957	5	4.1	6,289	7,475	$263,509	$313,202
1958	10	9.5	13,293	17,727	556,976	742,761
1959[c]	32	14.8	34,732	23,066	1,562,940	1,037,970

[a]Losses due to yellow dwarf in the Willamette Valley computed from survey.
[b]Losses from all causes for the State as a whole computed from crop reports.
[c]All yield data for 1959 are preliminary estimates by the crop reporting service.

In 1959 the total decrease in yield computed from the preliminary crop reports is less than the loss estimated for yellow dwarf in the Willamette Valley alone. This discrepancy may be accounted for in three possible ways: 1) The loss estimates for yellow dwarf are too high. 2) The yield estimates of the crop reporting service are too high. 3) The crop reports are based on acres actually harvested. Several oat fields in almost all of the 10 counties surveyed were not harvested, owing to severity of damage to the crop by the yellow dwarf virus. At the present time it appears that the preliminary estimates of the crop reporting service may be too optimistic.

This 1959 season was notable in several respects. Aphids were extremely abundant even when medium-early planted grain was just emerging from the soil. In most areas there were no "escaped" healthy plants by the time they were in the "boot" stage. Losses ranged from 6 to 50 percent for individual counties in 1959.

The impact of this disease on farmers and the general economy of western Oregon has not yet been fully appreciated. Almost half of about one million acres cultivated in this region is devoted to grain crops. The prospect of continued heavy losses with no immediate solution in sight places these farmers in a difficult position. There is need for intensive research on this problem.

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YELLOW DWARF ON BARLEY, OATS, AND WHEAT IN SOUTH DAKOTA IN 1959[1]

C. M. Nagel and George Semeniuk[2]

Barley yellow dwarf virus of barley, oats, and spring wheat occurred extensively in eastern South Dakota during 1959. The disease on all three cereals occurred in epiphytotic proportions. Symptoms on the various hosts appeared typical and clear-cut in all instances.

Infection in oat fields ranged from a trace to 90 percent; wheat, trace to 80 percent; and barley, trace to 50 percent. Percentage losses in the areas having the disease (Fig. 1) were estimated as follows: oats 50, wheat 30, and barley 20.

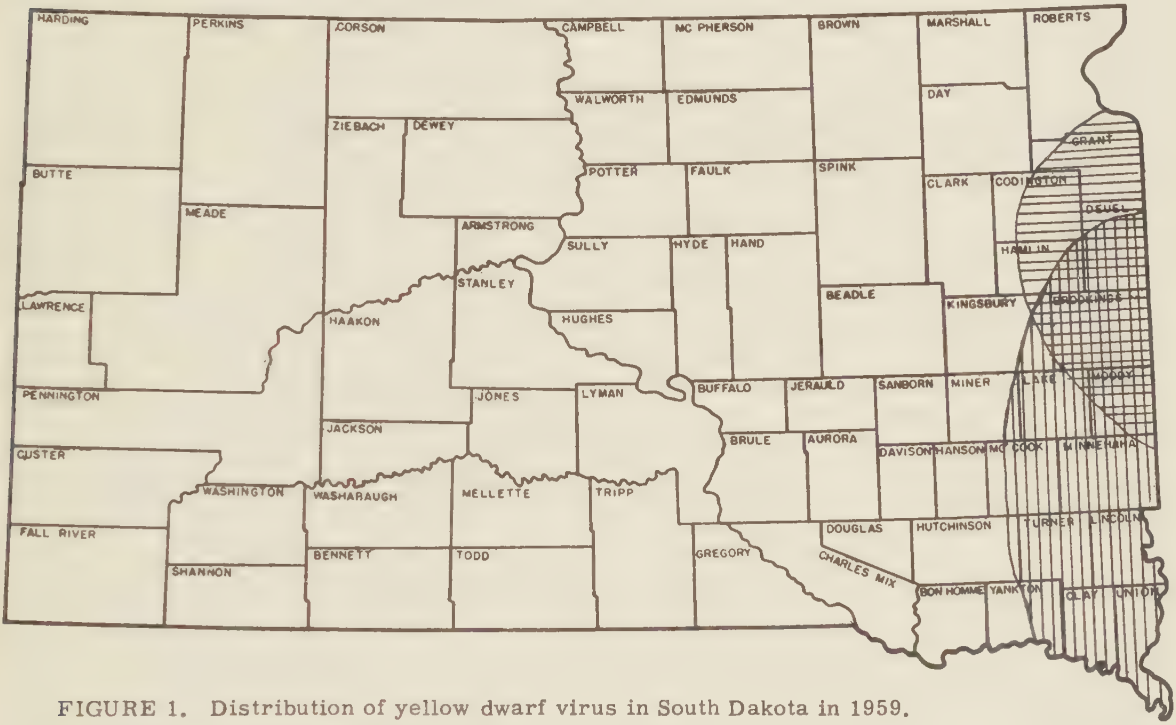

FIGURE 1. Distribution of yellow dwarf virus in South Dakota in 1959.

|||| = area where BYDV occurred on oats.

≡ = area where BYDV occurred on wheat.

▦ = area where BYDV occurred on barley, oats, and wheat.

The disease appeared following a moderate infestation of the grain aphid about May 20. The resulting damage by the BYDV at first was attributed by many growers to the aphids. This was understandable. Later, however, the growers were given the attendant conditions incident to the epiphytotic through information media. The disease occurred along the eastern end of the State and involved a strip about two counties in width.

SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION, BROOKINGS

[1] Journal paper No. 461, South Dakota Agricultural Experiment Station, Brookings, South Dakota.
[2] Pathologists, Plant Pathology Department, South Dakota State College.

YELLOW DWARF OF OATS IN TEXAS IN 1959

I. M. Atkins and M. C. Futrell[1]

Yellow dwarf of oats was observed in a number of fields of oats in Texas in 1959. Yellow dwarf virus was positively identified in six of seven leaf samples sent to W. F. Rochow, Department of Plant Pathology, Cornell University, Ithaca, New York. The disease usually occurred in small areas a few feet to several yards across where plants were stunted and badly discolored. The forage value of oats was reduced in these areas, and no doubt grain production also was reduced. Because of the spotted nature of infection and its confusion with nutritional and other problems, estimates of damage were very difficult. Several species of aphids were prevalent throughout the winter and spring over large areas in Texas. These included the greenbug, corn leaf aphid, and apple grain aphid.

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OBSERVATIONS ON CEREAL YELLOW DWARF OF OATS IN WASHINGTON IN 1959[1]

G. W. Bruehl and V. D. Damsteegt[2]

Cereal yellow dwarf is considered an endemic disease of small grains in western Washington and a potential epidemic disease of those hosts in the State east of the Cascade Mountains. The areas differ mainly because of differences in climate on the two sides of that partial barrier to the maritime Pacific air masses and the influence of the Japanese Current (1). As in most seasons, in 1959 yellow dwarf was widespread west of the Cascades in oats, wheat, and barley, and of little or no consequence in eastern Washington. Observations of yellow dwarf in western Washington were concentrated at the Southwest Washington Experiment Station, Vancouver. Some observations made there are reported below.

The aphids responsible for the spread of yellow dwarf in that area in 1959 were primarily of local origin. Nymphs and adults (parthenogenetic females) were observed in winter cereals at weekly or bi-weekly intervals all through the winter of 1958-1959, and in the very early spring. The egg stage was not necessary for the overwintering of the apple grain (Rhopalosiphum fitchii Sand.), English grain (Macrosiphum granarium Kirby), or the rose grass aphid (Macrosiphum dirhodum Walker) in this winter season, and the aphids overwintered in such numbers as to multiply quickly in the early spring.

Yellow dwarf in western Washington usually develops relatively evenly in entire fields, with little or no border effect along grassy roadsides or fence rows or spots to indicate foci of infection. This is taken as evidence of invasion by large flights of winged aphids, with the aphids distributing themselves among the young grain with uncanny uniformity. This uniformity of aphid distribution is most noted in relatively level fields. In the cool early spring the aphids tend to congregate and multiply on the warmer, sunnier exposures of hilly fields.

Aphid populations in spring oats fluctuated markedly in early spring, then seemed to stabilize at low to moderate levels for the remainder of the cereal growth period. Early seeded (April 6-9) spring oats were most heavily invaded. The aphid population reached a peak about May 1 to May 10, and then dropped abruptly. Oats seeded about May 1 emerged late enough to miss the greatest aphid invasion and they fared a little better, but such fields became completely infected by the yellow dwarf virus by the tillering stage. This greater invasion of early-seeded oats is at variance with experience in most regions and seasons.

In areas with frigid winters, spring seeding is delayed until the soil is thawed and then dried enough for seeding. The low temperatures of late winter and early spring prevent aphid multiplication so that these early-seeded fields escape early infestation, barring a migration of aphids from a warmer area. In contrast, western Washington soil is thawed in early spring and could be seeded except for an excess of moisture. Overwintered aphids multiply slowly during the prolonged period in which the moderately cool but damp soil becomes dry enough to permit tillage and seeding. Under these circumstances aphids of local origin are sufficiently abundant to infest even the earliest seedings of spring oats. In all probability seeding date cannot be used effectively as a means of control west of the Cascades in Washington.

An attempt to measure the loss from yellow dwarf in a field of Shasta oats by placing aphid-tight nylon mesh screen cages over the seeded oats prior to emergence was only partially successful. The caged oats remained aphid-free and developed no symptoms of yellow dwarf and were taller than uncaged oats, but they were somewhat pale and failed to tiller. Caged oats outyielded the uncaged oats by only 5 bushels per acre. A comparable shade was placed over some oats at 10 inches of height after they were showing symptoms of yellow dwarf and after two to three tillers per plant had developed. This shading resulted in taller plants but a yield reduction due to shading of 5 bushels per acre. As the shading by the cage decreased the yield of oats by at least 5 bushels, and the caging preventing infection increased the yield over the uncaged area by 5 bushels, the yellow dwarf loss was estimated at 10 bushels per acre. This 10 bushels per acre is believed to be an underestimation.

The active world spring oat collection of the United States Department of Agriculture was seeded in short rows for screening for yellow dwarf resistance. Albion, C.I. 729, the most

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[1] Scientific paper No. 1915, Washington Experiment Stations, Pullman. Work conducted under Project No. 1280, in cooperation with the Agricultural Research Service, Farm Crops Division.

[2] The authors wish to acknowledge the assistance of the personnel of Southwest Washington Experiment Station, Vancouver. Joseph C. Craddock of the United States Department of Agriculture furnished seed of over 3500 oat varieties for testing. R. M. Endo and D. C. Arny also kindly gave the authors seeds of some promising oats.

resistant common oat (*A. sativa*) found by Endo (2), in his study in Illinois, and Saia, C.I. 4639 (an *A. strigosa* selection) were seeded in every eleventh and twelfth row as standards. In this nursery of 3587 entries, 306 oats were judged equal to Albion and 139 superior to it. Saia was more tolerant than Albion. Victory, a variety commonly grown in this area, appeared equal or superior to Albion. It is apparent that selection must be made against local strains. Further testing is needed before a reliable rating of the 445 oats judged equal or superior to Albion in this preliminary screening is possible. *Avena strigosa* x *A. sativa* hybrid selections were not promising, as none of the resistance of the *A. strigosa* parent had been retained.

In a limited trial of winter oats, Ballard Selection (C.I. 6980) and Fulwin (C.I. 3168) were more resistant than Gray Winter oats, the local standard winter oats.

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YIELD OF CERTAIN OAT VARIETIES UNDER NATURAL EPIDEMIC CONDITIONS OF YELLOW DWARF (RED LEAF) VIRUS IN WISCONSIN, 1959[1]

H. L. Shands and L. G. Cruger

Summary

Commercial oat varieties grown in Wisconsin in 1959 showed different degrees of susceptibility, or perhaps tolerance, to the yellow dwarf virus. Estimated yield damage of 32 varieties at the Marshfield Branch Experiment Station where there was a natural epidemic gave a high negative correlation (-.90) with actual yield. Ajax, Beedee, Burnett, Fundy, Garry and Newton had less damage than some other commercial varieties. Some unnamed selections had about as much tolerance as the above varieties.

Ever since recognition of the viral nature of red leaf of oats there has been interest in obtaining varieties resistant to the disease. Several workers have published observations concerning reaction of a limited number of varieties. However, in 1957 Endo (3) summarized a 3-year study of the reaction of 4000 varieties of Avena sativa and other species to a moderately virulent strain of barley yellow dwarf virus. He inoculated in the three-leaf stage and found no immune or even highly resistant plants. He classified oat varieties in six reaction groups: extremely susceptible, very highly susceptible, highly susceptible, moderately susceptible, slightly resistant, and moderately resistant. In the last group he placed Saia (Avena strigosa, C.I. 7010), while Albion, C.I. 4918, and Fulghum were slightly resistant. Since he found so few resistant varieties, most workers are pessimistic concerning the value of this means of disease control.

Observations in Wisconsin in 1959 indicate the possibility of a practical type of tolerance to the yellow dwarf virus in certain commercial varieties. Evidence for this is the fact that farmers retained a good impression of the Beedee variety in 1959, even though the disease was seen in many oat fields.

LITERATURE REVIEW

Variety Reaction

Manns (5) in 1909 observed that oat varieties responded differently to blade blight. Although he believed that the blight was caused by bacteria, Manns made frequent reference to aphids and other insects. His descriptions suggest that he was working with yellow dwarf. In field plots Primus barley yielded only 9 bushels per acre while Oderbrucker produced 37.8. Wideawake oats yielded 55.2 bushels per acre compared with 73.5 for the Improved American variety. Two years earlier, Sixty Day oats yielded 57.0 bushels per acre, or 22.2 bushels more than the average of all varieties in the Ohio test plots.

In 1948 Rosen (7) described the red spot mosaic of oats in Arkansas. It is not known whether this was related to yellow dwarf. He noted that Traveler 15 oats was mixed in reaction and selected progenies from it that proved resistant. DeSoto and Victorgrain oats had no red spot. Rosen classified Lee, Custis, and Winter Turf as highly resistant. Several Red Rustproof strains showed only mild symptoms.

In 1952 Rosen (8) (after Oswald and Houston had clearly defined the barley yellow dwarf virus problem) found severe chlorosis in Nortex oats. Arkwin, Fulghum 708, Fulwin and an unnamed selection appeared highly resistant. Traveler 15-8, DeSoto, Victorgrain and Red Rustproof strains were susceptible. In 1953 Oswald and Houston (6) in California listed the reactions of a limited number of oat varieties. The tolerant varieties were Kanota and Bond. Those intermediate in reaction were Westdale, Ventura, Palestine, Custis, Lee, Richland and Victory. Others were highly susceptible, while California Red and Coast Black were stated to be extremely susceptible.

In 1955 Bruehl and Toko (2) stated that Bannock was the most tolerant variety available in their tests in Washington. Ajax, Andrew, Rodney and Roxton were fairly tolerant. Several highly susceptible varieties were Garry, Marida, Overland, Simcoe and Shelby. They used a

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[1]Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

Washington strain of the yellow dwarf virus and made comparisons with the findings of the 1953 work of Oswald and Houston (6). There was fair agreement with the barley tests, but not for some of the oat tests. Sill et al. (9) noted that Missouri 0-205 and Kanota were less susceptible to blue dwarf and red leaf than were Clinton, Nemaha and Cherokee. Working with aphid transmission of barley yellow dwarf virus of cereals in Ontario, Slykhuis et al. (11) used four oat varieties as test plants and found all highly susceptible. Clintland was more susceptible than Garry, Rodney or Winter Turf.

Yield Reductions

In 1957 Suneson and Ramage (10) in California found yellow dwarf yield reductions in California Red oats up to 88 percent, of which 60 percent could be accounted for in fewer seeds and 25 percent in less weight per seed. Thirteen oat varieties had an average of 26 percent yield reduction. California Red had significantly less yield in 2 years of a 6-year period than Kanota, which they considered tolerant to the disease. Bruehl et al. (1) compared yields of oats, barley and wheat grown for 4 years at three stations in western Washington. They noted that after a very severe freeze in the fall of 1955, aphids were scarce the following spring. Thus, in 1956, oats, barley and wheat all yielded much above the average at the three locations of Mt. Vernon, Puyallup and Vancouver. The mild winter of 1957-58 may have favored overwintering of aphids, and oats yielded only 16 bushels per acre at Puyallup in 1958 in contrast to 133 bushels per acre in the good year of 1956. Endo and Brown (4) inoculated Fayette, Clintland and Rodney varieties with yellow dwarf in the three-leaf and boot stages. In the three-leaf stage the varieties had yield damages of 92.5, 94.4, and 75.8 percent, respectively. However, when the plants were inoculated in the boot stage, Fayette suffered only 10.4 percent yield reduction, Clintland 21.8, and Rodney 15.0, and they averaged near 76 bushels per acre.

Thus, the virus can be very damaging to oats, and there appears to be some confusion in regard to varietal reaction. The general opinion prevails that nearly all common oat varieties are susceptible, but with a few exceptions.

OBSERVATIONS IN WISCONSIN

On July 13, 1959, when the writers were observing the Wisconsin State Uniform Oat Yield Nursery of 32 varieties at the Marshfield Station[2], yellow dwarf was much in evidence. There appeared to be a definite differential response of varieties and notes were taken on the basis of estimated yield reduction caused by the disease. The four-replication average of estimated reduction ranged from 18.8 to 52.5 percent. After the grain was threshed weights were determined, and it was found that the average yield for the nursery was 35.8 bushels per acre. The average estimate of yield reduction by the virus was 35.1 percent. A correlation coefficient was calculated between the actual yield in bushels per acre and the estimated yield reduction in percent. The correlation was -.90 with a regression of -.87 bushels for each estimated percent damage in yield (Fig. 1). Based on an extension of the regression line and comparative nursery yields of non-constant entries of barley and oat selections for the previous 10-year period, oat yields may have been reduced approximately 25 bushels per acre. One hybrid selection yielded only 18.8 bushels per acre. Fayette, Clintland and Clintland 60 were also low in yield. Clinton outyielded Clintland and Clintland 60 at both Marshfield and Ashland.

The varieties Ajax, Beedee, Fundy, Garry and Newton appeared to have definitely less damage than others. Two unnamed selections, C.I. 7372 (Vicland^{2}x Andrew-Landhafer sel.) and C.I. 7107 (Ajax x Hawkeye-Victoria), seemed to have less damage than average. C.I. 7372 is early and may have escaped for this reason. Beedee showed good production when serving as a "filler" for the nursery field.

Figure 2 illustrates guard rows of Clintland and Beedee oats. The amount of straw and grain of Clintland appeared to be definitely less than that of Beedee; Beedee produced 48.6 bushels per acre and Clintland 22.1. Figure 3 shows several consecutive plants taken from a Clintland guard row. The plants varied from only a few inches in height, for those with severe yellow dwarf damage, to tall plants with apparently little damage.

Somewhat similar observations were made at the Ashland Branch Station where the same varieties were included in the State Uniform Nursery. Instead of having a great deal of reddening of leaves and stunting of plants, Clintland and Clintland 60 had plants that appeared to be

[2]The cooperation of Russell Johannes in growing this nursery is acknowledged.

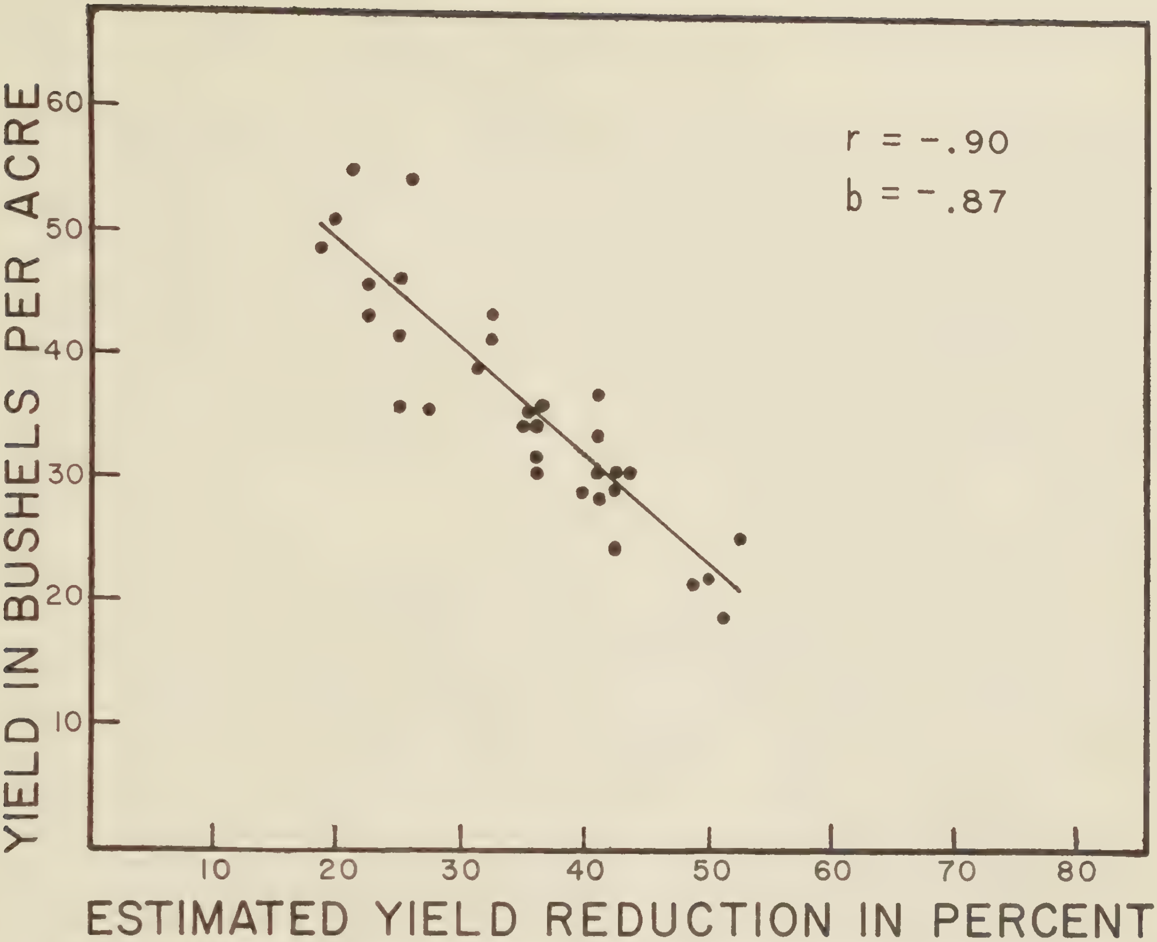

FIGURE 1. Yields of 32 oat varieties and their estimated percentage yield reductions during a natural epidemic of yellow dwarf at Marshfield, Wisconsin, 1959.

FIGURE 2. Guard rows of Clintland (left) and Beedee (right) at Marshfield, Wisconsin, where yellow dwarf was present, 1959.

FIGURE 3. Plants of Clintland with different severities of yellow dwarf infection, Marshfield, Wisconsin, 1959.

sprawled at the base and not as tall as in other tests. Furthermore, the plants seemed to have less seed per panicle, as well as an unproductive manner. This was verified also by the yield tests.

At the Ashland Station, X481-3, a selection from Arkansas 674 x C.I. 4629 (a Clinton type) growing in a Septoria test of L. S. Wood, appeared to be relatively free of red leaf. This observation will need further verification. In addition to those varieties found by Endo to be resistant, C. I. 1012 and C.I. 1050 from D. C. Arny appear to have resistance under field conditions. Albion, now in use as a resistance source, was grown on a million and a half acres in the North Central States in 1919. The selection and purification of the variety at Iowa was probably done during the "blade blight" years described by Manns. This suggests that red leaf may have helped separate adapted sorts a half century ago.

While it is realized that there may be many strains of the virus and that varieties may respond differently in different years, there seems to be a certain amount of tolerance in at least a portion of the commercial varieties now in use. It appears likely that some artificial tests for varietal reaction have been too severe, thus obscuring the responses of those varieties that may actually have enough low-grade resistance, or perhaps tolerance, to withstand modest virus infection in the field. This does not minimize the need for a good grade of resistance.

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OBSERVATIONS ON VECTORS OF BARLEY YELLOW DWARF VIRUS IN WISCONSIN

G. B. Orlob[1] and D. C. Arny

Observations on the populations of aphids which can carry barley yellow dwarf virus are of interest in connection with the widespread occurrence of the red leaf disease of oats in 1959, although direct evidence of virus transmission was obtained in relatively few cases. Certain grain aphids are endemic and appear in about the same numbers each year. These are, the English grain aphid (Macrosiphum granarium (Kirby)), the apple grain aphid (Rhopalosiphum fitchii (Sand.))[2], and the corn leaf aphid (R. maidis (Fitch)). The winged forms of these species usually appear during April, and for the apple grain aphid there is evidence that the earlier migrants are blown in from areas to the south. These aphids do not usually develop large populations, although the corn leaf aphid may build-up on barley and frequently does build-up on corn later in the season. Two other species, M. dirhodum (Wlk.) and R. poae (Gill.), are also vectors, but appear to be of little importance in the epidemiology of the disease.

The greenbug, Toxoptera graminum (Rond.), might be called an epidemic vector as it is rare in Wisconsin in most years but sometimes occurs in great numbers. In early May of 1959 winged migrants were carried into the State. In localized areas over the State the greenbug populations developed to high levels on the young oat plants and considerable feeding damage resulted. Increased incidence of red leaf of oats in 1959 has been largely attributed to the widespread occurrence of the greenbug, although in severe cases it was difficult to distinguish between damage caused by the virus, by aphids, and by drought.

An attempt was made to follow the development of aphid populations over a larger area of the country in the spring of 1959. In western and southwestern Arkansas[3] apterous R. fitchii and T. graminum were found on small grains from March 11-13 and alates were collected during early April. At Columbia, Missouri[4] peak numbers of greenbugs were obtained by sweeping on April 25 and in yellow pan traps during April 27-30. At Manhattan, Kansas[5] the peak collections of greenbugs in yellow pan traps were on April 29 and May 3. Large numbers of alate greenbugs appeared at Madison, Wisconsin from May 2-6. Since this period was characterized by strong southerly winds, these aphids were undoubtedly transported from areas considerably south of Wisconsin, where the aphid had already built up large populations. It has been reported that the greenbugs were blown into Minnesota from southwestern States between May 1 and 5[6]. Schafer et al.[7] reported an outbreak of greenbugs at Lafayette, Indiana during the second week of May.

If such cooperative aphid observations can be broadened, a much better understanding of aphid migrations will be obtained. The observations may also help to prevent damage from epidemics, both from the aphids themselves and from the barley yellow dwarf which they can introduce.

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[2]A very similar species, R. padi (L.), is also known to be a vector.

[3]Through the cooperation of G. E. Templeton, Department of Plant Pathology, University of Arkansas, Fayetteville, Arkansas.

[4]Through the cooperation of D. C. Peters, formerly Department of Entomology, University of Missouri, Columbia, and now at Iowa State University, Ames.

[5]Through the cooperation of R. H. Painter, Department of Entomology, Kansas State College, Manhattan.

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OAT YELLOW DWARF OR RED LEAF IN WISCONSIN IN 1959

D. C. Arny and H. L. Shands

Red leaf symptoms in oats, as observed by the writers, were more impressive in 1959 than in any time within the last quarter century in Wisconsin. The situation appeared to result, in large part, from the presence of the barley yellow dwarf virus, which is transmitted by several aphid species.

In the southern part of the State, except in the extreme southeast, the disease appeared late enough so that the crop was not severely damaged. In the central and northern regions symptoms were complicated by drought conditions and/or by greenbug (*Toxoptera graminum* (Rond.)) damage. Contiguous areas 5 to 10 miles in diameter seemed to have markedly different symptom expression, suggesting that yields or yield reductions were probably quite variable.

In spite of the rather poor appearance of the crop in many areas of the State, the Federal-State Crop Reporting Service's September estimate of yield of oats was 48.0 bushels per acre for 1959, as compared with 46.1 bushels for the previous 10-year average. Since the growing season was considered neither highly favorable nor unfavorable, the average damage from BYDV was probably near 5 percent for the State.

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